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SEPTOBASIDIUM IN THE UNITED STATES

By John N. Couch

Plates 1–44

INTRODUCTION

In Burt's (1916) monograph of *Septobasidium* eight species were described from the United States. Later (1921) Snell added one to this number. The genus has been considered as tropical or subtropical and of rather rare occurrence. The writer has found, however, that the genus is in reality quite abundant in the southeastern states and has been able, through the collecting of other mycologists and several extensive collecting trips of his own, to add twenty-six species to the nine already known to occur in the United States. Of these twenty-six species, six have been described before from other parts of the world, while the remaining twenty are being described for the first time. Except for five of the species all have been studied in the fresh condition and only one species in the sterile condition has been described as new, *S. Peckii*, and this is such a distinct one that it can readily be separated by vegetative characters alone from all other known forms.

In view of the relatively large number of new species from this region and the increasing recognition of the importance of *Septobasidium* in forest pathology, it seemed that a separate publication in a form readily available to the mycologist or forest pathologist of the species which occur in this region would be worth while at this time. In a later publication, which will perhaps be ready in a few months, all known species are to be described and illustrated.

The distribution of the species of *Septobasidium* by states is shown in the accompanying table. The most extensive collecting trips have

TABLE 1

DISTRIBUTION OF SPECIES OF SEPTOBASIDIUM BY STATES AS INDICATED BY THE NUMBER OF COLLECTIONS

	Va.	N.C.	Tenn	S.C.	Ga.	Ala.	Miss.	Fla.	La.	Tex	Ark.	Calif.	Pa.	N.J.	N.Y.	Canada	Total Coll.
S alni		several		9	1												
var. squamosum				6													
S apiculatum	1	27		3				2	1		1						
S canescens												5					
S Carestianum																7	
S castaneum		5		8	1	1	3	2	7								
S Cokeri	1	18						2						1			
S cremeum								2									
S Curtisii	2	60		14	6	2	2	6			3						
S filiforme	1	21															
S fumigatum				4	2			9	2								
S fuscum							1		1								
S grandisporum				1													
S Hesleri			2														
S Langloisii							6	13	2								
S lepidosaphis								2									
S Leprieurii				3			5	4									
S leprosum	1	6		2					1								
S lilacinoalbum		6		1													
S Mariani		14	2	1					4		1						
S Patouillardii		9		1				3	5								
S Peckii															1		
S pilosum								1	1								
S pinicola		1											several		several		
S pseudopedicellatum	4	30	2	4		1		14	12								
S rugulosum				2				3	1								
S sabalis									4								
S sabal-minor								1									
S Schweinitzii		10		1													
S sinuosum		3		14			3	11	8								
S Sydowii										1							
S taxodii									1								
S tenue				1			5	3									
S venosum		40		2	1	1			1								
Total species so far collected in each state	6	15	3	18	5	4	7	16	15	1	3	1	1	1	2	1	
	Va.	N.C	Tenn	S.C.	Ga.	Ala.	Miss.	Fla.	La.	Tex.	Ark.	Calif.	Pa.	N.J.	N.Y.	Canada	

been made in North Carolina, South Carolina, Florida, and Louisiana and this fact might well explain the greater number of species from these states than from Georgia, Alabama, Mississippi, and Texas. It is quite likely that as more collections are made in these latter states the number of species from them will be greatly increased. Only four species are known to occur in the northern states, but no one has made an extensive search for the genus in that region.

The commonest of all species appears to be *S. Curtisii* which occurs on twenty-eight different species of trees, its most frequent hosts being *Nyssa sylvatica* and *Fraxinus americana*. The next most abundant is *S. pseudopedicellatum* which occurs on twenty-three different species of trees, its most frequent hosts being *Fraxinus americana* and *Carpinus caroliniana*. *Septobasidium sinuosum* has been found on fifteen different trees but is most frequently found on *Quercus nigra* and *Liquidambar styraciflua*. *Septobasidium castaneum* occurs on fourteen different trees, but is usually found on *Quercus phellos*. Other species show a less wide range in the choice of tree and several have been found on only one species of tree, as, for example, *S. canescens* on *Quercus agrifolia*, *S. Carestianum* on *Cornus stolonifera* (in this country), *S. grandisporum* on *Cornus florida*, *S. Schweinitzii* on *Fraxinus americana* and *S. sabalis* on *S. Deeringiana*, etc.

In my collections seventy-six different species of trees have been found to be subject to attack by *Septobasidium*. Of these seventy-six, some are very subject to attack by the fungal-insect combination. Eleven different species have been found on *Magnolia virginiana*, and *Liquidambar styraciflua*, ten on *Cornus florida*, nine on *Quercus nigra*, eight on *Cornus stolonifera*, seven on *Quercus phellos* and *Hicoria alba*. The trees most subject to attack, however, are not always the ones which harbor the greatest number of different species. The species most subject to attack are *Fraxinus americana*, *Nyssa sylvatica*, *Magnolia virginiana*, *Quercus phellos*, and *Q. nigra*. Many species of trees and shrubs appear to be free from attack by *Septobasidium* and others may be practically free, as *Fagus grandifolia*, *Tilia* spp., *Juglans*, and *Azalea* sp., on each of which only one single collection has been reported (Table 2).

Nineteen different species of scale insects have been found associated with *Septobasidium* in this region. The following table shows a partial list of species of *Septobasidium*, the scale insects with which they are associated and the host plants on which they occur.[1] Some species

[1] The scale insects have been identified by Dr. Harold Morrison, Bureau of Entomology, U. S. D. A., Washington, D. C.

HOST TREES OF SPE

| Species of Septobasidium | Host Trees | Acer floridanum | Acer negundo | Acer rubrum | Acer saccharinum | Albizzia | Alnus incana | Alnus rugosa | Aristolochia | Azalea | Betula | Carpinus caroliniana | Ceanothus | Cercis canadensis | Citrus aurantifolia | Citrus grandis | Citrus sinensis | Cornus Amomum | Cornus florida | Crataegus | Fagus grandifolia | Fraxinus americana | Gleditsia triacanthos | Hicoria alba | Hicoria aquatica | Hicoria glabra | Ilex decidua | Ilex opaca | Juglans nigra | Liquidambar styraciflua | Liriodendron tulipifera | Magnolia grandiflora | Nyssa aquatica | Nyssa sylvatica | Persea pubescens | Pinus echinata | Pinus palustris | Pinus taeda | Platanus occidentalis | Populus deltoides | Prunus serotina | Quercus alba | Quercus coccinea | Quercus falcata | Quercus laurifolia | Quercus lyrata | Quercus marilandica | Quercus michauxii | Quercus nigra | Quercus phellos | Quercus prinus | Quercus rubra | Quercus stellata | Quercus velutina | Rhus copallina | Rhus glabra | Rhus toxicodendron | Robinia pseudacacia | Salix nigra | Sassafras officinale | Taxodium distichum | Tilia americana | Ulmus alata | Ulmus americana | Ulmus fulva | Ulmus rubra | Vaccinium arboreum | Vaccinium corymbosum | Vaccinium stamineum | Vitis rotundifolia | Zanthoxylum clava-herculis | Zanthoxylum fraxineum |
|---|---|---

OF SEPTOBASIDIUM

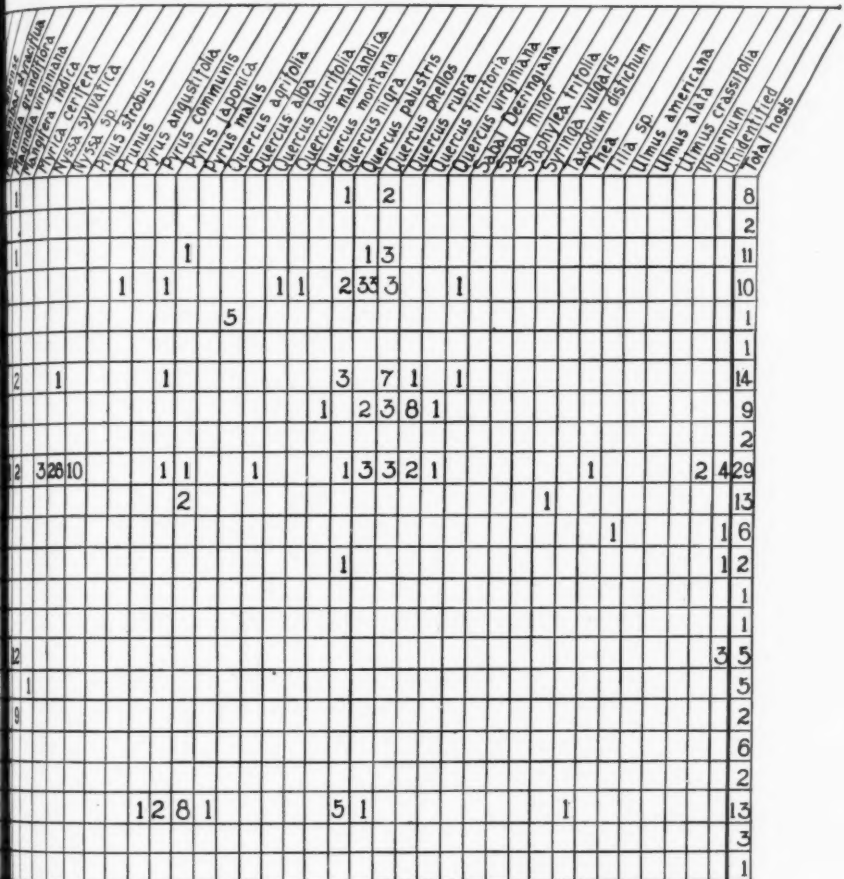

TABLE 3

TABLE SHOWING PARTIAL LIST OF SPECIES OF SEPTOBASIDIUM, THE SCALE INSECTS WITH WHICH THEY ARE ASSOCIATED, AND THE HOST PLANTS

FUNGUS	INSECT		HOST PLANT
S. Cokeri	8394	*Aspidiotus osborni*	*Cornus florida*
		Aspidiotus juglans-regiae	Same tree as above
S. pseudopedicellatum	8245	*Chionaspis gleditsiae*	Ironwood
	8402	*Aspidiotus* sp.	Sweet gum
	8483	*Aspidiotus diffinis*	Bay
	8461	*Aspidiotus juglans-regiae*	*Cornus florida*
S. filiforme	8263	*Aspidiotus ancylus*	New Jersey tea
	8272	*Aspidiotus juglans-regiae*	*Cornus florida* ?
		Aspidiotus ancylus	Same tree as above
	8237	*Chionaspis gleditsiae*	Ironwood
	8273	*Aspidiotus juglans-regiae*	Redbud
	9077	*Aspidiotus forbesi*	Jap. quince
S. pinicola	11246	*Chermes* sp. apparently	White pine
S. Curtisii	8294	*Chionaspis sylvatica*	Black gum
	8457	*Chionaspis sylvatica*	Oak
	8376	*Chionaspis gleditsiae*	Ash
S. grandisporum	8465	*Chrysomphalus obscurus*	*Cornus florida*
S. apiculatum	8344	*Chrysomphalus tenebricosus*	*Cornus amomum*
		Aspidiotus ancylus	Same tree as above
	8484	*Aspidiotus diffinis*	Sweet bay
	8492	*Aspidiotus osborni*	Pin oak
S. leprosum	8302A	*Aspidiotus ancylus*	*Cornus florida*
S. sinuosum	8467	*Aspidiotus lataniae* (not typical)	Latex plant
	8478	*Aspidiotus osborni*	Water oak
	8321	*Aspidiotus forbesi*	Amer. holly
	8466	*Aspidiotus osborni*	Oak
	8316	*Aspidiotus juglans-regiae*	Sweet gum
	5934	*Aspidiotus liquidambaris*	Sweet gum
		Aspidiotus juglans-regiae	Sweet gum
	4955	*Chionaspis gleditsiae*	Ironwood
S. Schweinitzii	8408	*Chionaspis gleditsiae* ?	Ash
	8398	*Chionaspis gleditsiae* ?	Ash
	8379	*Chionaspis gleditsiae* ?	Ash

TABLE 3—*Concluded*

TABLE SHOWING PARTIAL LIST OF SPECIES OF SEPTOBASIDIUM, THE SCALE INSECTS WITH WHICH THEY ARE ASSOCIATED, AND THE HOST PLANTS—*Concluded*

FUNGUS	INSECT		HOST PLANT
S. alni	8485	*Aspidiotus osborni*	Water oak
	8482	*Aspidiotus diffinis*	Sweet bay
	8481	*Aspidiotus osborni*	Willow oak
	8324	*Aspidiotus ancylus*	Hickory
	8325	*Aspidiotus liquidambaris*	Sweet gum
	8327	*Aspidiotus forbesi*	Amer. holly
	8323	*Chrysomphalus obscurus*	Willow oak
	8437	*Aspidiotus ancylus*	Pecan
	8479	*Aspidiotus liquidambaris*	Sweet gum
		Aspidiotus uvae	Sweet gum
S. Patouillardii	8396	*Chionaspis gleditsiae*	Ash
S. castaneum	8480	*Aspidiotus osborni*	Willow oak
	8453	*Aspidiotus juglans-regiae*	Black gum
	8451	*Aspidiotus osborni*	Oak
S. Mariani	8182	*Aspidiotus osborni*	White oak
	8447	*Aspidiotus forbesi*	Jap. quince
	8276	*Aspidiotus juglans-regiae*	Blue dogwood
	8377	*Aspidiotus juglans-regiae* (all 2nd stage)	Deciduous holly
	8400	*Aspidiotus juglans-regiae*	Sweet gum
S. sabalis	9151	*Aspidiotus* (?) *sabalis*	*Sabal Deeringiana*

as *S. sabalis*, *S. Schweinitzii*, etc., which occur on only one host plant are associated with only one species of scale insect. Other species which are found on a wide variety of host plants may be associated with several species of scale insects, e.g. *S. alni* and its variety *squamosum* are associated with seven different species. In some cases, as in *S. apiculatum* on *Cornus amomum*, as many as three different species of scale insects have been found under the same specimen, *Aspidiotus ancylus*, *Chrysomphalus obscurus*, and *Parlatoria proteus* but only individuals of the first were parasitized. *Septobasidium Curtisii*, which usually occurs on ash and black gum with *Chionaspis sylvatica*, may also parasitize species of *Aspidiotus*, as for example *Aspidiotus perniciosus*. From the results so far obtained it appears that the greater number of species of *Septobasidium* are not limited to an association with one scale insect but may be associated with several.

The size, structure and color characters in *Septobasidium* are of considerable diagnostic importance. The different species vary greatly in size, some being characteristically small and inconspicuous, as, for example, *S. sabal-minor*, *S. apiculatum*, *S. Hesleri*, *S. pilosum*, etc. Other species though forming small patches of growth may, because of the large number of patches formed, be quite conspicuous, e.g. *S. Burtii*. Other species form large and conspicuous patches of growth, e.g. *S. pseudopedicellatum*, *S. grandisporum*, *S. castaneum*, *S. sinuosum*, *S. Langloisii*, etc. Some species show a characteristic definiteness of shape and have a sharply delimited margin, while in other species the margin may be indeterminate and the outline of growth quite irregular. The thickness of the growth is also characteristic for the different species, some producing patches the top surfaces of which stand up from the bark as much as two or three millimeters, as, for example *S. grandisporum* or *S. fumigatum;* while other species may be so thin as to appear as mere discolorations on the surface of the bark, as, for example, *S. tenue*.

Just as the different species vary in size they also vary strikingly in the structure of the context. About half of the species described below show three distinct structural regions or layers. First the subiculum which is next to the bark and from which arises the second layer composed of vertical pillars or columns of hyphae. From the tops of the pillars arises the third layer which extends as a flat roof over the tops of the pillars. Some of the species with pillars have three horizontal layers: the subiculum, the top layer, and then another, incompletely formed layer parallel to these two and slightly raised above the subiculum. *Septobasidium pseudopedicellatum* and *S. Cokeri* are excellent examples of forms in which there are two horizontal layers and in which the pillars are very conspicuous. *Septobasidium Mariani* and *S. castaneum* illustrate types with three horizontal layers. The size and structure of the pillars vary greatly in the different species and are therefore of considerable diagnostic value.

The species in which pillars do not occur show such enormous variations in vegetative structure that space does not permit a detailed discussion.

In reproductive structures the various species show wide variation. All species so far found in the United States form basidia except two which apparently produce only conidia.

The basidia show eight distinctly different types as indicated in the list below. The probasidial cell may be present or absent. If present, it may persist as an empty cell at the base of the basidium or it may

elongate and become septate to form the basidium. The basidia may be one, two, three, or four-celled, straight or coiled. By far the commonest type is that with a straight, four-celled basidium with a persisting probasidial cell.

(1) Basidia 1-celled, with persisting probasidial cell.
S. grandisporum.
(2) Basidia 2-celled, without persisting probasidial cell.
S. Patouillardii.
(3) Basidia 2-celled, with persisting probasidial cell.
S. sabalis, S. Langloisii, S. sinuosum.
(4) Basidia 3-celled, without probasidial cell.
S. apiculatum.
(5) Basidia 3-celled, with probasidial cell.
S. canescens.
(6) Basidia 4-celled, without probasidial cell, basidia coiled.
S. Schweinitzii, S. lilacinoalbum, S. Hesleri, S. rugulosum, S. tenue.
(7) Basidia 4-celled, with probasidial cell, basidia straight.
S. fumigatum, S. leprosum, S. Cokeri, S. Curtisii, S. lepidosaphis, S. alni, S. alni var. *squamosum, S. Carestianum, S. Leprieurii, S. castaneum, S. Burtii, S. pseudopedicellatum, S. sabal-minor, S. pinicola, S. Mariani, S. fuscum.*
(8) Basidia 4-celled, with probasidial cell, basidia coiled.
S. filiforme, S. taxodii, S. Sydowii, S. cremeum.

All species which I have studied in detail, *S. Burtii, S. pseudopedicellatum, S. Cokeri, S. apiculatum, S. Schweinitzii, S. Patouillardii, S. filiforme, S. Curtisii,* and *S. lilacinoalbum,* are perennial. Such species undergo a regular cycle of development. In this region the probasidia are formed during late fall and winter, being mature and ready for germination in early spring. The probasidia germinate and the basidia are formed during wet weather throughout the spring and early summer. With the coming of spring, the fungus starts new growth, the growing continuing during the summer and early fall. In the greater number of species a new zone of growth appears around the margin. In some species in addition to a new marginal region of growth an entirely new top layer of growth may be formed over the old layer. Growth is characteristically slow in all species, amounting to only a few millimeters each season.

I have found in *S. Burtii* that the spores when mature are shot away from the sterigmata in the same manner as described by Buller (Researches, Vol. 2) for various Basidiomycetes. A small droplet of liquid suddenly appears at the spore-hylum. This droplet increases in size until it becomes about equal to one third the volume of the spore

and then suddenly the spore and droplet disappear. The spores are shot away so quickly that one cannot follow the course of one spore but one can see a single spore as it suddenly flicks across the field of view.

If the spore falls in a situation favorable for germination, as the moist surface of the bark or the moist surface of the fungus which bore it or on a slide in a damp chamber or on suitable culture media, it first becomes once, thrice, or many times septate. The number of septations in the spores seems in most species to be correlated with the number of septations in the basidium, i.e. the fewer septations in the basidium the greater the number of septations in the spore. After becoming septate the spore gives off bud cells as first described by Coker (Journ. E. M. Sci. Soc. **35**: 126. 1920). On nutrient agar the spores may, after a period of several weeks budding, give rise to mycelial threads. Some species, however, continue to produce bud cells on nutrient agar even after being in culture over a year. In culture all of the species which have been tested grow very slowly, producing after a year a circular area of growth only two or three centimeters wide. In none of the cultures so far have any reproductive structures appeared. A more complete report will be given on culture work later.

In nature the further fate of the bud cells is known only in *S. Burtii* (= *S. retiforme* of American authors). In this species the young insects when crawling about over the fertile surface of the fungus accidentally pick up the bud cells which germinate and enter the young insects' haemocoel. (Couch, Quart. Journ. Micros. Soc. **74**: 383–437. 1931). This appears to be the only way in this fungus by which infection occurs. Through such infected insects, old colonies are renewed and new colonies are established. Though the same symbiotic relationship appears to exist in all the other species which are associated with scale insects, I have so far been unable to determine how the young become infected in any species other than *S. Burtii*.

The haustoria within the parasitized scale insects are very highly specialized as to structure, being perhaps the most highly specialized haustoria in all the fungi. The type of haustorium has been found to be constant in any one particular species, even in the species of *Septobasidium* which are associated with several different species of scale insects and since haustoria are always present, while the reproductive structures are not, the structure of the haustorium is of great diagnostic value in separating species, and sometimes even in determining if a particular fungus belongs in the genus or not. Five types of haustoria have been recognized: (1) the glomerulus type, e.g. *S. pinicola;* (2) irregular, long

coil type, e.g. *S. pseudopedicellatum*,—commonest type; (3) regular coils connected by fine threads and spindle-shaped segments, e.g. *S. Burtii*; (4) tufts of hyphae composed of spindle-shaped segments connected by fine threads, e.g. *S. apiculatum*,—a common type; (5) threads composed of spindle-shaped segments which give rise to branches of the same structure but which coil, e.g. *S. fumigatum*.

It has also been found that the mode of connection between the haustoria within the insects and the external fungus is characteristic for certain groups of species. Four different types of connections have been found: (1) Connections passing through dermal pores; (2) through skin by the mouth; (3) through vaginal pore; (4) through anus, and sometimes through both anus and vaginal pore.

All species of *Septobasidium* which I have studied cause damage to the trees on which they grow, the damage being due not to the fungus directly but to the combination of fungus and scale insects. The one exception to this is *S. polypodii* which directly parasitizes the sori of a species of *Polypodium* and is not associated with scale insects. In such species as *S. apiculatum* where the growth covers a small area the damage is slight but in the greater number of species the growth may be quite extensive, in which case the damage is considerable. I have seen numerous small trees of *Fraxinus* and *Nyssa* killed outright by *S. pseudopedicellatum* and *S. Curtisii*. Large trees of both these genera may be heavily infected in which cases they are very unhealthy, showing many dead limbs. Types of wood injury are shown in several of the photographs (plates 3, 5, and 11).

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SEPTOBASIDIUM Pat.

Fungus body usually resupinate but very variable; dry, crustaceous or spongy. In the commoner species composed of three regions: the subiculum which grows over the bark, the middle region composed of upright slender pillars or thick pillars or mounds or ridges of hyphae which support the top layer in which the hymenium is formed. In some species the context is more or less compact throughout. Threads septate, without clamp connections. Probasidial cell undergoing a long period of rest before germinating, or elongating immediately into the basidium; probasidial cell sometimes lacking. Basidium usually transversely septate into two, three, or four cells, rarely one-celled, straight or curved. Spores elliptic or bent-elliptic, colorless, becoming divided into two to many cells soon after formation and budding numerous sporidia if kept moist. Inhabiting the stems, branches, leaves, and sometimes the fruits of living woody plants and generally symbiotically associated with scale insects, some of which are parasitized, others of which are left to reproduce; but sometimes directly parasitic on plants

Widely distributed in the tropics and the warmer regions of the temperate zone.

KEY TO SPECIES OF SEPTOBASIDIUM IN THE UNITED STATES

I. Color whitish to pale buff when fresh
  A. Fungus body large and conspicuous, up to 10 or more cm. in area
    1. Pure white throughout when fresh, becoming pale buff in old condition. Pillars conspicuous. Probasidial cell present, basidia straight, 4-celled.....*S. Cokeri* n. sp. p. 40
    2. White with a tint of lilac (summer condition), mummy brown with whitish margin (winter condition), pillars less conspicuous than above and becoming dark colored. No probasidia, basidia coiled, 4-celled.....*S. lilacinoalbum* n. sp. p. 56
  B. Fungus body small and inconspicuous, less than 10 cm. in area
    1. Pure white when fresh, pale buff on aging, the top surface cut up into areas about 1 square mm. in extent. Pillars very inconspicuous. Probasidia present, basidia straight, 4-celled
S. leprosum n. sp. p. 42
    2. Cream colored when fresh, becoming clay colored when old, subiculum white. Pillars very inconspicuous, surface smooth or cracked, context thin, up to 225μ thick, probasidia present, basidia coiled.....*S. cremeum* n. sp. p. 46
    3. White when fresh, becoming rich buff with splotches of olive due to presence of algal cells. No pillars, context homogeneous throughout. Probasidia present, basidia straight, 3-celled.
S. canescens Burt. p. 62
    4. White when fresh and remaining white or becoming buff; context very thin, without pillars, but with mounds capped by one or more spines which are about 1 mm. high. No persistent probasidial cell, basidia 3-celled, straight
S. apiculatum n. sp. p. 62

II. Color buff to dark brown

A. Fungus body large and conspicuous, up to 10 or more cm. in area

1. Light buff to chestnut brown, with a smooth and shiny surface; pillars very conspicuous, straight, unbranched, dark brown, the subiculum white, probasidia present, basidia 4-celled, straight.....*S. pseudopedicellatum* Burt. p. 20

2. Buffy brown to dark brown, pillars conspicuous, branched and entangled, dark brown, often with conspicuous marginal rhizomorphs. Probasidia and basidia as above
S. Mariani Bres. p. 16

3. Vinaceous buff to wood brown. Pillars less than 1 mm. tall, unbranched and inconspicuous. Probasidia present, basidia 2-celled. On leaves and petioles of *Sabal*..*S. sabalis* n. sp. p. 69

4. Rood's brown to clay color, surface shiny and smooth except for cracks and holes. No pillars but tufts of hyphae present in young regions. Probasidia and basidia as in *S. pseudopedicellatum* Burt.....*S. Leprieurii* Pat. p. 27

B. Fungus body usually smaller than 10 cm. in area

a. Usually a millimeter or more thick

1. Buffy brown or darker, with conspicuous radiating ridges and depressions, no pillars. Probasidia and basidia as above.....*S. Burtii* Lloyd. p. 22

2. Dark brown in center, the surface strigose towards periphery, no pillars. On *Pinus strobus*.....*S. pinicola* Snell. p. 19

3. Deep brown with a grayish surface, which is irregularly split by deep fissures. Context very compact, without pillars. Probasidia present, basidia 4-celled, coiled. Hymenium with characteristic straight paraphyses
S. Sydowii n. sp. p. 47

4. Deep brown, about Van Dyke brown. Surface with numerous, erect, densely arranged, anastomosing spines, which may present an irregular honey-comb surface or may be covered by a hymenial surface. Probasidia present. Basidia straight, 4-celled.....*S. lepidosaphis* n. sp. p. 35

b. Usually less than 1 mm. thick

5. Cream color to buffy brown or cinnamon brown, margin frequently irregular in outline, pillars present but very indistinct. On *Cornus stolonifera* in America. Probasidia present, basidia 4-celled, straight
S. Carestianum Bres. p. 29

6. Cinnamon brown to burnt umber, margin usually regular in outline, frequently with a lighter, yellowish marginal zone. Pillars present but less distinct than above. Usually on *Quercus* and *Hicoria* in America. Probasidia and basidia as above but basidia larger.....*S. alni* Torrend. p. 32

7. Pale buff in young specimens with a wide whitish margin, becoming wood brown to army brown, sometimes with a dusky purplish tint in fresh material. Hymenium with

numerous very delicate, fragile threads with deep brown contents. Probasidia present, basidia coiled, 4-celled
S. filiforme n. sp. p. 49

8. Grayish brown, the top surface incompletely formed, thus presenting a flaky or squamose appearance. Pillars absent or very inconspicuous. Probasidia present, basidia straight.....*S. alni* var. *squamosum* n. var. p. 35
9. Tawny olive to sepia, context compact, 60–250μ thick, surface minutely retiform, margin fibrillose, basidia 4-celled, coiled, without probasidial cell..*S. rugulosum* n. sp. p. 59
10. Dirty Mars brown, sometimes concolorous with bark, very thin and difficult to distinguish. Probasidia present, basidia 4-celled, coiled. On *Taxodium*
S. taxodii n. sp. p. 48
11. Tawny to russet, top surface composed of flat, sinuose, anastomosing plates, in section 500–1000μ thick. Hymenium composed of compacted upright threads
S. Peckii n. sp. p. 75
12. Russet, spongy cottony in texture, on fruits of *Sabal minor*
S. sabal-minor n. sp. p. 19

III. Color gray or grayish brown to slate gray to grayish lavender

A. Fungus body large and conspicuous, more than 10 cm. in area

1. Smoky gray, the hymenium about mouse gray, the sterile parts about mummy brown or nearly black on *Cornus*. In section 600–1400μ thick, no pillars. Probasidia present. Basidia 4-celled, straight. Usually on *Acer* sp...*S. fumigatum* Burt. p. 44
2. Violet plumbeous or grayish blue, top surface composed of sinuose plates or frequently cracked in old regions. Margin blackish with distinct rhizomorphs.....*S. Langloisii* Pat. p. 67
3. Pale mouse gray to purplish gray, surface with sinuose, anastomosing ridges the sides of which are rounded
S. sinuosum n. sp. p. 65

B. Fungus body small and inconspicuous, less than 10 cm. in area

1. Mouse gray with brownish tint. Surface with minute (0.2-0.4 mm. wide) darker colored elevated mounds. In section 100–225μ thick, compact. No probasidia, basidia coiled
S. tenue n. sp. p. 58
2. Pallid purplish gray to snuff brown. Surface flaky. Margin dotted with minute pillars. In section 250–400μ thick. No probasidia, basidia 4-celled, coiled....*S. Hesleri* n. sp. p. 54

IV. Color brown with a purplish tint or nearly black

A. Fungus body large and conspicuous, up to 10 cm. or more in area

1. Chocolate brown, nearly black when wet, surface smooth and shiny, 1–1.5 mm. thick. Margin with three horizontal layers. Pillars usually indistinct. Probasidia present, basidia 4-celled, straight.....*S. castaneum* Burt. p. 25
2. Nearly black with a purplish or bluish tint, sometimes fuscous,

200–400μ thick, pillars usually inconspicuous. Probasidia with a roughened wall, basidia 4-celled, straight
S. Curtisii (B. & D.) B. & S. p. 37

3. Clove brown or Brussel's brown. In section 125–200μ thick, no distinct pillars present. Probasidia present, basidia straight, 4-celled ..... *S. fuscum* n. sp. p. 15
4. Sterile parts blackish brown, spongy, hymenium pale smoke gray, margin with distinct rhizomorphs, in section up to 2.5 mm. thick; basidia one-spored ..... *S. grandisporum* n. sp. p. 72
5. Brownish with a purplish tint, with a smooth velvety surface. Margin finely fimbriate and with a whitish zone 2–4 mm. wide, without marginal pillars but with "pup-tent"-like structures. No probasidia, basidia 4-celled, coiled
S. Schweinitzii Burt. p. 52

B. Fungus body usually less than 10 cm. in area

1. Blackish brown. Context compact. No probasidia or basidia seen but abundant, small, oval, thin-walled conidia
S. conidial form n. sp. (unpublished)
2. Blackish brown with a velvety appearance and purplish tint or sometimes even lighter to snuff brown. Pillars slender, subiculum tan. No persistent probasidial cell, basidia 2-celled
S. Patouillardii Burt. p. 70
3. Deep brown, forming minutely setose, small patches 1–10 mm. wide. Septate, coiled conidia formed; no probasidia or basidia seen in American material ..... *S. pilosum* B. & S. p. 73

Septobasidium fuscum n. sp.

Plates 13 and 24

Fungus body resupinate, very closely adherent to the bark; covering areas equal to several hundred square centimeters; clove brown, fuscous or Brussel's brown (Ridgway). Surface characteristically smooth except for irregularities in the bark, minute holes and elevated patches of coarse, loosely entangled hyphae. Beneath each of these patches is a scale insect. Margin usually indeterminate, composed of branched threads. In section 125–200μ thick, composed of three indistinct regions: (1) the subiculum, composed of a few branched threads about 4.2–5.8μ thick, rarely up to 6.3μ thick which adhere closely to the bark; (2) upright hyphae arising from the subiculum and branching out to form (3) the top layer; top layer 60–85μ thick, composed of branched hyphae recurved at the tips, hyphae 2.2–3.5μ thick, probasidia and basidia in various stages of development. Probasidium spherical or slightly subspherical, 10–12.6μ thick, sprouting and emptying its entire contents to form a cylindrical 4-celled basidium which is 4.2–5.4 x 35–40μ; sterigmata 4–5μ long. Spores 4–5 x 6–13.4μ, bent-elliptic.

Symbiotically associated with *Aspidiotus diffinis* Newst., some of which are parasitized by very regular coils which are connected by ex-

tremely fine threads and spindle-shaped cells, as in *S. Burtii* Lloyd; other insects are free from parasitism and are in all stages of development.

This remarkable species has appeared only twice but because of its thin structure, it may be easily overlooked as a discoloration on the bark. It may be distinguished from other species by its thin structure, clove brown color, and by the minute elevated patches of hair-like hyphae which cover the scale insects. Microscopically it may be distinguished from all other species except *S. Burtii* by the very regularly coiled haustoria connected by fine hyphae and spindle-shaped cells.

Specimens examined:

Mississippi: Near Pascagoula, Jan. 1, 1932, with *Aspidiotus diffinis* Newst., J. N. Couch, coll., 9192. Type.

Louisiana: Near Baton Rouge, on *Quercus*? Dec. 31, 1931, J. N. Couch, coll., 9177. Differs from the type in being wood brown to Brussels' brown (Ridgway) and in the absence of the patches of loosely woven threads which cover the insects.

Septobasidium Mariani Bres. Ann. Myc. **1**: 24. 1903. Diagnosis in Ann. Myc. **3**: 164. 1905.

Sense of Bresadola and Patouillard, not Bourdot and Galzin.

Plates 4, 26, and 44

Fungus body perennial, resupinate, forming patches sometimes as much as 10 cm. long, often girdling the limbs. Composed of two distinct zones: (1) the older central part over which the hymenium has been formed and (2) the marginal region. Central region typically dark brown during the summer, becoming somewhat fleshy brown and later buffy brown in fall and retaining the lighter color until after the spore-bearing period in the spring. Surface of central region irregular and granulose in fall when forming, becoming smooth and shiny and finally becoming split by irregular cracks. Marginal region very distinctive and peculiar, deep brown in color (darker than central portion) except for the very narrow, outer, growing zone which is whitish; about 1 cm. wide in late summer, hardly over 2 mm. wide by late winter due to the formation of new hymenium; marginal region often higher than the central region, composed of a basal subiculum, over which extend numerous dark colored rhizomorphs. From the upper sides of the rhizomorphs plates of horizontal threads grow outward. Where the plates come in contact with each other, they fuse, thus forming a layer over the subiculum. This condition is distinct at the outer growing margin. From the older portion of the marginal region a vast tangle

of much branched and anastomosing pillars arise. The pillars branch out at the top giving rise to the hymenial surface. In section up to 2 mm. thick, stratose in older portions. In younger regions composed of (1) a basal subiculum which extends over the bark and over which numerous branched dark brown rhizomorphs extend, subiculum thin, about 25–30μ thick; (2) a region of very short stout pillars which arise from the subiculum and which with the rhizomorphs support (3) an incompletely formed layer parallel to the subiculum (the scale insects are located between the subiculum and the second layer), space between subiculum and second layer about 100μ high; the second layer and the rhizomorphs give rise to (4) the long, branched, slender, anastomosing pillars, often about 1 mm. tall, 15–60μ thick, threads of pillars 3.8–4μ thick, septate, without clamp connections, the pillars giving rise to (5) the top layer which bears the hymenium. Hymenium 50–90μ thick, composed of rather compact, branched threads, 2.2–3.5μ thick, from the sides of which the probasidia arise; probasidia pyriform, 6.7–8.4 x 10.9–18.9μ, giving rise to a long, straight, cylindrical 4-celled basidium about 4.2–4.6 x 42–50μ; spores (no. 8400) bent-elliptic, white, 3.8–4.2 x 12.6–21μ.

Symbiotically associated with several species of scale insects some of which are parasitized by irregular, coiled hyphae, others of which are left unparasitized. In this species the threads which connect the coiled haustoria of the fungus within the insect with the fungal pad which envelops the posterior part of the parasitized insect pass through either the anus, the genital pore, or through the thin cuticle by the mouth.

The most remarkable characteristic of this plant is that it is composed of three distinct stories: i.e., there is the basal subiculum (the first story) covering the bark, next a region of short, thick pillars and rhizomorphs and then another layer (the second story) parallel with the subiculum, and arising from this layer is a region of long branched pillars on the tops of which is borne the top layer (the third story). This characteristic can easily be recognized with a hand lens in material collected from mid-summer until early winter and serves to distinguish this species from all but a few species of *Septobasidium*. Another characteristic by means of which this plant may be distinguished is the peculiar marginal condition of plants collected in the late summer and early fall. At this time the new hymenium for the following year has not begun to develop and the new zone of growth between the margin of the old hymenium and the outer margin is composed of a dense tangle of dark colored pillars and rhizomorphs.

I have often found this species growing on the limbs along with typical *S. pseudopedicellatum* Burt and because of the similarity of color in some

lots of material the two plants may easily be confused, as has been done by previous students. Typical *S. pseudopedicellatum* Burt is a rich, buffy brown color on top with much darker brown, usually straight, and unbranched pillars, and with a white subiculum. (For further distinctions between this species and *S. pseudopedicellatum* Burt, see under the latter species.)

This species like all the others which I have studied is distinctly perennial. We have collections from around Chapel Hill during every month in the year. Moreover I have kept several specimens on *Pyrus japonica* marked in the arboretum for several years. The fungus has a very different appearance in winter and spring from that in the summer and fall, so different, in fact, that one would almost certainly describe the forms collected during these two seasons as distinct species. It is only by keeping the same specimen under observation for several years that one may prove that such apparently distinct fungi are merely stages in the development of the same fungus.

Widely distributed and fairly common in some localities.

Specimens examined:

Italy: Near Rome, on *Pyrus communis*, 1902, Mariani, (Patouillard Herb., Harvard Univ., and N. Y. Bot. Gard. Herb.) Type or co-type.

Caucasus: Near Suchum, on *Pyrus communis*, July 1915, W. Siemaszko, 9954.

Brazil: Near Bono Principio, 1928, J. Rick, Farlow Herbarium, also U. N. C., 9358, sterile.

North Carolina: Chapel Hill, on *Pyrus malus*, 4157, and on *Quercus nigra*, part of 3936 large piece, four other collections on *Quercus*, 8182, 8378, 8405, 9708. On *Pyrus japonica*, eight collections; on *Cornus florida*, 8253, 8395, 9898; on *Cornus amomum*, 8276, 9113; on *Ilex decidua*, 8377; on *Liquidambar styraciflua*, 8400, 9332.

South Carolina: Society Hill, on *Pyrus angustifolia*, July 22, 1922, J. T. Rogers, U. S. D. A. Herbarium and U. N. C., 9955.

Tennessee: Sevierville, on *Acer* sp., L. R. Hesler, two collections (Univ. Tenn. Herb. 538 and 540), U. N. C., 9709 and 9710.

Louisiana: Opelousas, on *Crataegus*, April 16, 1932, C. L. Shear (U. S. D. A. Herb.) and U. N. C., 9707, on *Taxodium distichum*, April 16, 1932, P. R. Miller (U. S. D. A. and U. N. C. Herb.), near Baton Rouge, on *Crataegus*, Dec. 31, 1931, J. N. Couch, 9165 and 9173.

Arkansas: Near Little Rock, on *Quercus phellos*, April 12, 1933, Dow V. Baxter, 9376.

Septobasidium pinicola Snell. Mycologia **14**: 55–60, pls. 11–13. 1922.

Plates 7 and 18

This species has been so fully described by Snell that I can add but little to his observations.

Fungus body resupinate, forming small (2–3 cm. in diameter) roundish patches in the angles of the limbs on *Pinus strobus*. Army to natal brown in the central part with a lighter buff-colored margin. Surface smooth at first but becoming strigose toward the marginal region, usually remaining smooth in the center. The margin 1–2 mm. wide and more or less smooth. In section 400–1500 mm. thick, lacunar, spongy, not distinctly divided into regions. Hyphae 3–7.1μ thick, usually about 4.2μ thick, much septate, without clamps, sometimes slightly constricted at the joints, walls of hyphae slightly thinner than usual in the genus. Probasidia borne over entire plant body in my specimens, usually globose, 14–16.8μ thick but sometimes subglobose, 13–16 x 15–20μ, hyaline, germinating and becoming entirely empty to form a cylindrical, 4-celled basidium 6–7.5 x 58–70μ, sterigmata about 8μ long. Spores 3–4.4 x 13–21μ, bent-elliptic.

Associated with an aphid relative (*Chermes* sp.), some of which are parasitized by irregular hyaline coils, each coil being shaped like the glomerules of a kidney, while other insects are not parasitized.

Easily distinguished by its usual habitat on *Pinus strobus*, its color, small size, and general appearance.

Described from New England and New York where it appears to be common (Snell). For collection data from this region see Snell, 1922. It has also been collected in Pennsylvania several times by Overholts and at Highlands, N. C., August 4, 1931, by me. Also on *Pinus monticola* from Idaho, coll. by Weir. In Mo. Bot. Gard. Herb., U. N. C. Herb., and Snell Herbarium.

Septobasidium sabal-minor n. sp.

Plates 14 and 22

Fungus body forming small, brownish, cottony, resupinate growths on the stems, leaves, and fruits of *Sabal minor*. The patches on the fruit are from 3 to 10 sq. mm. in area and always surround the pedicel scar. Margin determinate, surface spongy. In section up to about 1 mm. thick, not composed of distinct regions. Threads of context 3.6–4μ thick. Hymenium rather indistinctly set apart from the context, composed of sparingly branched hyphae, probasidia and basidia. Probasidium spherical to pyriform, 8.4–10.5 x 10–12μ, frequently with an

enlarged subtending cell, germinating and emptying its entire contents to form the basidium. Basidium cylindrical, divided by three transverse walls into 4 cells, 4–4.6 x 33–42μ. Sterigmata 4–5μ long. Spores bent-elliptic, no septate ones seen.

Associated with scale insects, *Aspidiotus* (?) *sabalis* Comst., some of which are parasitized by irregular coils. This species somewhat resembles *S. sabalis* in gross structure and resembles *S. alni* in the structure of the probasidia, basidia, and spores, but can easily be distinguished from both of these species.

Collected only once and then by Miss M. L. Bomhard on the fruits of *Sabal minor*, 15 miles north of St. Augustine, Fla., Nov. 20, 1933. Type in U. N. C. Herbarium 9719, and in U. S. D. A. Herbarium, Washington, D. C.

Septobasidium pseudopedicellatum Burt. Ann. Mo. Bot. Gard. **3**: 327. 1916.

Plates 10, 11, 27 and 35

Fungus body resupinate, forming small to very extensive, conspicuous, foliose crusts on the bark and leaves of a great variety of trees and shrubs. Individual patches of growth up to 15 or 20 cm. in greatest dimension. Color very variable: light buff, or pale, smoke gray to cinnamon brown or chestnut brown. Hymenial surface smooth and usually shiny even under a lens, sometimes cracked and wrinkled in old specimens, in certain young specimens before the hymenium is formed the surface may be velvety or alveolate. Margin usually determinate, varying in appearance at different times of the year, subiculum of margin typically whitish, sometimes buff. Marginal region usually conspicuously marked by numerous upright pillars; however, in some conditions the top layer may extend out even with the subiculum obscuring the marginal pillars. Margin of upper layer sometimes fimbriate. In section 0.7–1.5 mm. thick, composed of three distinct layers or regions: (1) the very thin whitish subiculum which extends over the bark, threads of subiculum 3.4–4μ thick, often covered with minute crystals; from the subiculum arise the pillars which compose the (2) middle region. Pillars simple or branched in the older parts, sometimes arising in concentric rows on the margin, erect, 0.5–1.2 mm. tall, usually about 1 mm. tall by about 40–60μ thick, composed of parallel, septate, mostly unbranched hyphae about 3.7–5.5μ thick; brownish with a tuft of whitish threads at the base, the white threads encrusted with minute crystals. The pillars branch out above to form (3) the top layer over which the hymenium is formed. Top layer stratose in old specimens by the formation of several hymenial layers; up to 300μ thick, composed of loosely packed, branched and entangled, brownish threads, 3.7–5.5μ thick; giving rise to the hy-

menium, which because of its densely packed and entangled, colorless paraphyses and probasidia is sharply differentiated from the underlying brownish threads, hymenium 35–50μ thick; paraphyses or sterile threads about 4μ thick at their origin and tapering down to about 2μ thick, wavy; probasidia usually subglobose or pyriform, sometimes globose, 11.5–13.8 x 16–22.2μ, giving rise to a straight, cylindrical basidium, 4.8–7 x 37–70μ, usually 6 x 60μ, thickest in the middle or toward the distal end, usually with a long stalk from which it frequently separates at maturity. Sterigmata 4–5μ long, lateral or sometimes terminal on the end cell. New probasidia may sometimes be formed within the old ones, such secondary probasidia giving rise to smaller basidia, which bear small spores. Spores white in print, bent-elliptic, 3.7–4.8 x 16–23μ (the few spores seen in the type material agree), rarely up to 5 x 30μ, becoming 4–8-celled.

Associated with a variety of scale insects on the leaves and bark of many kinds of trees and shrubs (*Fraxinus* spp., *Alnus* spp., *Pyrus* spp., *Quercus* many species, *Cornus, Hicoria, Carpinus, Liquidambar, Nyssa, Gleditsia, Acer, Crataegus, Betula, Magnolia, Ilex, Citrus, Taxodium, Staphylea trifolia*, and other wild and cultivated genera). Some of the scale insects are parasitized by haustoria in the form of irregular coils; other insects are free from parasitism.

This species in its commonest and typical form may easily be identified by the buffy to cinnamon brown color of the top layer, and its smooth surface; the dark colored erect pillars with the tuft of whitish threads at their bases, and by the thin, whitish subiculum. The pillars are always quite distinct in this species and it is unfortunate that it has the name *S. pseudopedicellatum*. The hymenial characters are also distinctive. The hyaline elements of the hymenium contrasting strikingly with the brownish underlying tissue, the subglobose or pyriform probasidia, the cylindrical, 4-celled basidium with its short sterigmata, and the wavy, tapering, hyaline threads help one to recognize this fungus.

This species may be distinguished from *S. Mariani* Bres., with which it frequently occurs, by the densely crowded, branched and entangled pillars and the minute, dark colored, marginal rhizomorphs of the latter. *Septobasidium Mariani* also frequently has an extra horizontal layer between the subiculum and hymenium. The reproductive structures of the two fungi are similar.

Widely distributed throughout the southeastern United States, reported as far west as Wisconsin and as far north as New Jersey. Perhaps the commonest species of this region. Also occurring on *Citrus* in Brazil, perhaps imported into that country on diseased *Citrus* stock. Represented by sixty-seven collections in our herbarium.

Specimens examined:

North Carolina: Common in piedmont and coastal regions.

Virginia: Near Roanoke, on *Carpinus*, April 21, 1931, C. L. Shear, 9940; near Burkeville, Va., July, 1928, on *Cornus*, *Liquidambar*, and *Hicoria*, J. N. Couch, coll.

South Carolina: Common in piedmont and coastal regions. Near Myrtle Beach, on *Cornus amomum*, Aug. 28, 1931, J. N. Couch, coll., 9090; also on *Fraxinus*, 9092; near Charleston, on *Cornus florida*, March 19, 1929, J. N. Couch, coll., 8483; St. Helena's Island, on *Magnolia virginiana*, March 21, 1929, J. N. Couch, coll., 8462.

Florida: Common as far south as Sebring, J. N. Couch, coll.; Gainesville, on *Acer rubra*, Knight, coll. (Herb. of the University of Florida, 9189); on *Fraxinus*, A. S. Rhoads and E. West, colls. (Herb. of the University of Florida); also two collections from Weber on *Fraxinus* (Herb. of the University of Florida, 9411 and 9413); on orange leaves, F. A. Wolf, coll.; Homestead, on *Citrus grandis*, Link, coll. (Herb. of the University of Florida, 9187); also on *Citrus sinensis* (Herb. of the University of Fla., 9186).

Brazil: Estado de Minas Gerais, Viçosa. On *Citrus*, referred to *S. albidum* in Phytopathology **23**: 734–737, 1933. Albert S. Müller, coll. (Müller Herb., 44). Dr. Müller has very kindly supplied me with abundant material which is in fruit and agrees well with *S. pseudopedicellatum* Burt.

Campo Grande, Rio de Janeiro, abundant on stems, twigs and leaves of *Citrus*. June, 1934. Nearch Azevedo, coll. Dr. Silveira Grillio, comm. Referred to *S. albidum* (Estudo sobre *Septobasidium albidum* da Laranjeira. Agronomia **1**: 265–276, 2 pls. 1930.)

Septobasidium Burtii Lloyd. Mycological Notes **7**: 1286, fig. 2902, plate 296. 1924. *S. retiforme* of American authors but not of Patouillard.

Plates 1 and 28

Fungus body resupinate, forming rather tough and hard, more or less circular patches of growth, varying from 0.1–15 cm. in diameter, sometimes even larger, the patches sometimes anastomosing so that large limbs or trunks of small trees may be almost covered by the fungus. Color typically brown, the younger parts drab, the older darker brown, frequently mottled with lighter and darker spots. In some specimens the color is grayish. Margin characteristically determinate and whitish during the growing season. Surface typically formed of branched ridges

which radiate in an irregular fashion from the center outwards. Between the ridges are valleys which are partially covered by thin flaps. The surface is also frequently marked by fairly distinct annual, concentric growth zones which are usually 2–3 mm. wide. The outer margin of the concentric growth rings are usually bordered by the above mentioned flaps. In section up to 2 mm. thick, composed of three regions: (1) the subiculum, forming a thin (35–60μ thick), closely adherent mat of densely packed threads on the surface of the bark and from which arise (2) the numerous anastomosing ridges composed of compacted more or less upright hyphae (about 4μ thick) which give rise to and support the top layer. Between the ridges are tunnels which radiate back toward the center; (3) top layer which varies from a fraction of a mm. up to 1.5 mm. thick. The lower surface of the top layer is black. The entire layer is composed of compacted hyphae which are of rather uniform diameter, 3–4.2, usually about 4μ thick, branched and with frequent septa, extending in a more or less vertical direction. Threads throughout brownish except in the regions of new growth where they are hyaline. Hymenium formed over the top layer 40–65μ thick, composed during the fertile season of probasidia and basidia in various stages of development and recurved hyaline hyphae. Probasidia hyaline, subglobose, ovoid to pyriform, most frequently ovoid, 8–12 x 16–24μ, sprouting to form a cylindrical, thrice septate basidium. Basidia usually with a long stalk 8–15μ long, pointed at the distal end, thickest in the middle, frequently separating from the stalk when mature, 6–8 x 50–65μ. Each cell of the basidium gives rise to a short sterigma on the end of which is borne a spore. Spores usually dividing into four cells if kept in a damp chamber and then giving rise to numerous, minute, bud cells.

Symbiotically associated with scale insects (*Aspidiotus osborni* and sometimes *Chrysomphalus obscurus*), some of which are parasitized by haustoria in the form of very regularly coiled hyphae, each coil being connected by a fine thread; the coiled hyphae eventually connecting with hyphae composed of spindle-shaped cells joined by fine threads. Some insects are not parasitized and are to be found usually in all stages of development.

This species is quite distinct from *S. retiforme* (Berk. and Curtis) Pat. (Bull. Soc. Myc. Fr. **16**: 55, 1900-no. 384 in Cuban Fungi represented by two collections, nos. 288 and 214, in the Kew Herbarium and Curtis Herbarium, one of which, No. 214, is not a *Septobasidium* but either a sterile lichen or blue green alga), as was first noted by Lloyd (1924). *Septobasidium Burtii* is usually predominantly drab with a dark brown center, while *S. retiforme* is cinnamon brown with a powdery gray sheen. The shape of growth also differs: in *S. Burtii* the growth is usually circular, in *S. retiforme* of irregular shape. The surface of *S. Burtii* is

reticulately veined, the veins are rounded and adjacent veins are connected by a rather thin layer of hyphae and thus the top layer forms a continuous covering except for numerous holes which are partly covered by flaps; thus the subiculum in *S. Burtii* is not exposed except at the margin. In *S. retiforme* the surface is also reticulately veined but the surface of the veins is somewhat flattened without rounded edges, and the subiculum between the veins is exposed. In texture *S. Burtii* is hard and tough while *S. retiforme* is soft and flocculent. Unfortunately no one has seen mature basidia in *S. retiforme* but in some of the pieces of No. 288 the probasidia have elongated to form immature twisted basidia, some of which have become once septate. The probasidia and basidia of *S. retiforme* are quite distinct from those of *S. Burtii*. Furthermore, in *S. retiforme* the hyphae are loosely packed and frequently curved somewhat circinately and extend upwards at an angle of about 45°; in *S. Burtii* the hyphae are closely packed, and more or less straight and vertical. The hyphae of *S. Burtii* are slightly thicker than those of *S. retiforme*. In section the thickness of *S. Burtii* is characteristically variable due to the elevated ridges and depressions, being up to 2 mm. thick; in *S. retiforme* the thickness varies from 250–400μ. A very striking difference between the two fungi is in the haustoria. In a small fragment of *S. retiforme*, No. 288 from Patouillard's herbarium, one parasitized scale insect was found and upon soaking in KOH and then crushing, the haustoria were seen to be in the form of irregular coils as in *S. pseudopedicellatum*, thus proving beyond possibility of doubt that the fungus which has been called *S. retiforme* in the United States is quite distinct from the *S. retiforme* (B. & C.) Pat.

This species is easily recognized by its circular shape, tough, hard texture, drab color and reticulately veined surface.

It causes marked damage to infected trees, badly infected limbs being killed after three or four years. Numerous spraying experiments have been carried out with this fungus over a period of several years but the only satisfactory way of eradicating the fungus and insects is to prune the infected limbs.

Coker (1920) first found and illustrated the germinating probasidia, basidia, and spores. Other studies showing the symbiotic relationship between the scale insects and fungus in this species have been published by the writer (1929, 1931).

This is one of the commoner species of *Septobasidium*, having been reported from the District of Columbia southward into Florida and westward as far as Texas. It is such a common and distinct species

that I have taken only a few specimens on my collecting trips, hence my collection data give no conception of its abundance.

Specimens examined:

North Carolina: Near Chapel Hill, over forty collections during all seasons on *Quercus palustris, Q. phellos, Quercus* sp., *Liquidambar styraciflua, Acer saccharinum, Pyrus communis,* and other unidentified hosts; Smith Island, on *Quercus virginiana,* Dec. 28, 1921, J. N. Couch, coll., 5927.

South Carolina: Near Charleston on *Quercus nigra,* March 1930, J. N. Couch, coll. Near Springwood, on *Pyrus communis,* July 2, 1928, J. N. Couch, coll., 8737.

Georgia: Near Wrens, on *Quercus nigra,* March 11, 1932, J. N. Couch, coll., 9227.

Alabama: Near Auburn, on *Prunus,* 1897, Earle and Baker, colls. In New York Bot. Gard. Herb. A variety with nearly smooth surface.

Louisiana: Near St. Martinsville, 1890, Langlois, coll. (Flora Ludoviciana, No. 2233), in New York Bot. Gard. Herb. Apparently this is the collection seen by Patouillard and identified by him as *S. retiforme* (B. & C.) Pat. (Bull. Soc. Myc. de Fr. **16:** 55. 1900).

Brazil: Near Sao Paulo, on *Meliaceae,* Nov. 6, 1934, J. Rick, coll., 9894. Agrees with typical material except spores and basidia larger. Spores 4.2–5.4 x 21–29.4μ; basidia 8.4–9.2 x 50–63μ.

Septobasidium castaneum Burt. Ann. Mo. Bot. Gard. **3:** 319. 1916.

Plates 3 and 25

Fungus body resupinate, growing in large patches and often covering an area equal to several square feet; not rarely extending in effused patches from the base of a tree nearly to the top. Chocolate brown when dry, becoming nearly black when wet. Surface typically smooth and shiny, sometimes with cracks or pin holes. Margin distinctly fimbriate, mostly concolorous with the surface except in rapidly growing specimens and then nearly white in the growing region, determinate; typically with stout or slender pillars from near the bases of which arise horizontal hyphae which extend out, anastomose at the tips forming a second layer parallel to the subiculum; from the tops of the pillars threads extend out horizontally forming the top layer; in the older parts this middle horizontal layer is usually quite indistinct. Thus there are three horizontal layers as in *S. Mariani.* Margin of top layer at times extending out over the margin of bottom layers; margin sometimes with

an irregular honeycomb appearance. In section 1–1.5 mm. thick, often stratose by the formation of several fruiting layers in old specimens; composed of three regions: (1) the subiculum made up of a compact layer of threads which grow over the surface of the bark, 30–50μ thick; (2) the middle region which at first is composed of upright inconspicuous pillars or tufts of hyphae not grouped into pillars; pillars becoming indistinct as the fungus develops, the spaces between them being nearly filled by the growth of hyphae until in the older parts of specimens the middle layer is more or less continuous with the subiculum and top layer; (3) the hymenial layer which is about 30–40μ thick and is composed of probasidial cells, basidia, and simple hyphae; probasidia usually subglobose, quite irregular in shape, the large functional cell frequently subtended by a somewhat smaller swollen sterile cell 10–14.7μ, most about 12μ thick, thick-walled, sprouting under proper conditions to form a cylindrical basidium; basidia 5–6.7 x 37–50μ, becoming thrice septate, i.e. divided into four cells, each cell bearing a spore on short sterigma. Spores 3.8–4 x 11–14.2μ, bent-elliptic, usually not becoming septate.

This species shows considerable variation in color shade even on the same host, but can be recognized and distinguished from the related species by the following combination of characters: deep brownish chocolate color, inconspicuous pillars, peculiar margin, and comparatively small spores which do not become septate. For a comparison with *S. Leprieurii* (Mont.) Pat., to which this species is most closely related, see under *S. Leprieurii*.

This is one of the commoner species of *Septobasidium*, being by far the commonest species in the eastern part of South Carolina, so far as my observations go. By far the commonest host is the willow oak (*Quercus phellos*). The worst infected trees are the young ones with trunks from one to five inches in diameter. The trunks of such trees are often nearly girdled with the fungus from near the base almost to the top. Such trees are very unhealthy, with numerous dead branches.

Specimens examined:

Alabama: Near Montgomery, Dr. R. P. Burke, Mo. Bot. Gard. Herb., 20421 (type) and 20693, part of type in Farlow Herb.

North Carolina: Near Beaufort, very abundant on *Quercus rubra*, *Cornus florida*, *Ilex opaca*; specimens on *Ilex* associated with *Aspidiotus forbesi* Johns, J. N. Couch, coll., Aug. 3, 1929, several specimens fertile; near Wilmington, on *Quercus virginiana*, Dec. 28, 1921, Couch and Grant, colls., 5932, sterile; near Magnolia on *Quercus* sp., A. C. Mathews, coll., 9969.

South Carolina: Near Cheraw, Pee Dee River swamp, abundant on

Quercus phellos, June 29, 1928, A. B. and J. N. Couch, colls., 8318; near Georgetown, on *Hicoria*, 8329; also on *Quercus phellos*, *Ilex opaca*, 8332 and 8330, *Magnolia virginiana*, 8331; on *Pyrus communis* in orchard, half dozen trees noted all infected, 8336; on *Nyssa sylvatica*, 8328; near Clemson College, on *Azalea* sp., Feb. 19, 1932, Mr. Lutken, coll., sent by G. M. Armstrong, 9225. Mr. Lutken reports that the fungus was abundant, killing entire plants.

Georgia: About 19 miles east of Valdosta, on *Quercus*, March 19, 1932, J. N. C., 9299.

Florida: Homestead, on *Albizzia* sp., with *Aspidiotus herculeanus*, March 9, 1933, spores forming, Univ. Fla. Herb., 9024; also common on *Quercus* sp., *Liquidambar*, *Ilex*, and other species as far south as Sebring, J. N. Couch, coll. Gainsville, on *Quercus nigra*, Feb. 22, 1935, G. F. Weber and E. West, colls., Univ. Fla. Herb., 9966.

Mississippi: Near Pascagoula, on *Magnolia virginiana*, 9201, mixed with *S. Leprieurii* (Mtg.) Pat., not typical; on *Quercus*, 9208; on *Fagus*, 9182, Jan. 1, 1932, J. N. Couch, Coll.

Louisiana: Baton Rouge, on *Liquidambar*, Jan. 8, 1932, C. A. Brown No. 327, not typical, apparently a cross between *S. castaneum* and *S. Mariani*; near Madisonville, on *Quercus nigra*, C. A. Brown No. 320, typical; near New Orleans, several collections on *Cornus* and *Quercus*, J. N. Couch, coll., Dec. 31, 1931.

Septobasidium Leprieurii (Mont.) Pat. Bull. Soc. Myc. Fr. **16**: 54. 1900.

Plates 2, 3, and 25

Fungus body resupinate, covering extensive areas, up to 10 or 15 sq. cm., on the bark of living trees. Bister, Rood's brown, or clay color to tawny olive (Ridgway). Surface inherently smooth and velvety but frequently with pin holes and numerous sinuous or anastomosing cracks due to the incomplete formation of the top layer; in old specimens the surface frequently becomes broken by numerous fissures. Margin determinate, in some specimens the margins of both the top and bottom layers end abruptly at the same place as in the type material, without pillars, but with irregular small (about 1 mm. wide) plates of hyphae which arise from the subiculum and grow upward and backward to unite with the margin of the top layer. These plates are partly supported by tufts of hyphae. In section 500–800μ thick, frequently stratose due to the formation of more than one hymenial layer. Composed of three regions in the younger parts: (1) a subiculum from which

arise (2) the short, scattered, tufts of hyphae which in turn give rise to and support (3) the top layer. In the older parts the tufts of hyphae are inconspicuous, due to the growth of hyphae which more or less fill the space between the tufts. The middle region is thus composed of a spongy context. Hyphae of context brownish, septate, about 4.2μ thick. Hymenium 33–44μ thick, composed of recurved threads, and probasidia and basidia in various stages of development. Probasidia globose to pyriform, sometimes subtended by an enlarged cell, 9–10μ thick, giving rise to a cylindrical, 4-celled basidium 4.2–4.6 x 28–35μ, probasidium remaining as an empty cell after the formation of basidia. Basidia usually falling away from probasidia, leaving a short stalk attached to the latter. Sterigmata arising laterally, one from each cell; spores small, bent-elliptic 3.8–4 x 11–13μ, rarely becoming septate.

Associated with scale insects (*Aspidiotus diffinis*), some of which are parasitized by irregularly coiled hyphae.

Until studying the type of *S. Leprieurii* (Mont.) Pat., I have considered the present species as a hybrid form of *S. castaneum* Burt and have segregated it with the latter species. Unfortunately the type material of *S. Leprieurii* is sterile (I found one basidium, 4-celled, cylindrical, 5 x 33μ) but some of my collections (Nos. 8317, 9254) agree almost perfectly with the type in color and vegetative structure. The type material is bister to Rood's brown with a smooth shiny surface. There are no pillars but only short tufts of hyphae toward the margin. These tufts can only be seen by turning over the top layer. The margins of both top and bottom layers end abruptly at the same place as in some of my specimens. In the older regions the context is composed of loosely packed hyphae and is stratose in places by the formation of more than one hymenial layer. Hyphae of type about 4.2μ thick. From the similarities in appearance and vegetative structure of the type of *S. Leprieurii* and the present species it is almost certain that they are the same but this can only finally be decided by the collection of fertile material of *S. Leprieurii* from the type locality.

The present species is very closely related to *S. castaneum* but may be distinguished from that species by the larger size, thicker structure, darker color, and larger probasidia, basidia, and spores of the latter. Typical *S. castaneum* is chocolate brown with a faint tint of purple, while *S. Leprieurii* is bister or Rood's brown, sometimes almost clay color. The marginal conditions of the two plants are also very distinct. In *S. castaneum* there are pillars on the margin and usually three horizontal layers are evident towards the margin, while in *S. Leprieurii* no pillars are evident and there are only two horizontal layers near the

margin. Also in *S. castaneum* the marginal region is frequently distinctly fimbriated or sometimes fibrillose, while in *S. Leprieurii* the margin is smooth or indistinctly fimbriate, except with a lens. The two species occur in the same region but usually on different trees, *S. castaneum* most frequently being found on *Quercus*, while *S. Leprieurii* is usually on *Magnolia virginiana*. In one of my collections on *Magnolia virginiana*, however, both species occur, in some places actually growing intermingled.

Specimens examined:

Guiana: Perhaps type, in Patouillard Herbarium, Harvard Univ.

Guadalupe: Near San José, on *Erythrina*, May 1915, Condert, coll. There are two species in this material. The black one is *S. Curtisii* (not typical) and the chocolate brown one is perhaps *S. Leprieurii*. In color this resembles *S. castaneum* Burt but its very thin structure and lack of pillars suggest *S. Leprieurii*; another collection from the same locality on one of the Loranthaceae, May 1909, No. 151, is quite distinct from the type material of *S. Leprieurii*, in Pat. Herb. at Harvard Univ.

South Carolina: Near McBee, on *Magnolia virginiana*, June 30, 1928, J. N. Couch, coll., 8317, fertile; near Bethune, on *Magnolia virginiana*, March 20, 1932, J. N. Couch, coll., 9299, probasidia and basidia as in 8317, clay color.

Florida: Near Homestead, on *Albizzia* sp., with *Aspidiotus herculeanus*, March 9, 1933, O. D. Link coll., Univ. of Fla. Herb., 9024, U. N. C., 9362; near Avon Park on *Magnolia virginiana*, March 13, 1932, J. N. Couch, coll., 9254; near Kissimmee, March 13, 1932, J. N. Couch, coll., 9238.

Mississippi: Pascagoula, very common on *Magnolia virginiana*, Jan. 1, 1932, J. N. Couch coll., Nos. 9184, 9188, 9201 (with *S. castaneum*), 9205, 9207.

Septobasidium Carestianum Bres. Malpighia **11**: 16. 1897.

Plates 6 and 20

This species has been collected in the western hemisphere only by Dr. John Dearness in Canada and by Padre J. Rick in Brazil.

Fungus body perennial, resupinate, covering an area of several (2–6) square centimeters on the bark of living shrubs and trees. Color quite

variable: about cream color in young specimens, becoming buffy brown and sometimes cinnamon brown. Surface inherently smooth but often with minute pin holes or irregular fissures due to the incomplete formation of the top layer, the latter condition being particularly noticeable in young specimens. Margin determinate or often indeterminate and irregular in outline due to the formation of isolated patches of hymenium. In section 250–700μ thick, often stratose, the primary stratum usually composed of three indistinct regions (in old, well developed specimens the subiculum, middle region, and top layer may be continuous): (1) the subiculum, usually exceedingly thin, hardly exceeding 10–15μ thick in young specimens, in older specimens 30–60μ thick, very compact, hyphae of subiculum about 3–4μ thick, minutely rough; (2) the middle region which is composed of loosely packed, ascending, septate, pale or nearly hyaline hyphae about 3–4μ thick without clamp connections and arranged in short cone-shaped tufts or in thick short pillars, the hyphae passing into and forming (3) the top layer over which is formed the hymenium; top layer 110–210μ thick, composed of branched septate hyphae, hymenium sharply demarked from the top layer by a region of densely packed, entangled, darker colored threads at the base of the hymenium, usually 35–40μ thick but often up to 170μ thick in old specimens, hymenium at first composed of hyaline, loosely packed, slightly curved threads, 2–3μ thick, and irregularly arranged probasidial cells, in old specimens exceedingly compact, composed of densely packed threads, probasidia, and irregular branched cells which perhaps are probasidia which failed to germinate normally. Probasidia usually with a distinct stalk, often borne in clusters, usually pyriform, 6–8 x 11–14μ, germinating to form a club-shaped basidium which is thickest at the distal end. Basidia 4.2–5 x 33.6–47μ, 4-celled. Spores about 4 x 14.7μ, bent-elliptic (only a few seen).

Associated with *Chionaspis corni* Cooley, some of which are parasitized by irregularly coiled hyphae, while others are left to reproduce.

In material collected in the fall, the healthy scale insects on the bark as well as beneath the fungus are exceedingly abundant. Beneath practically all the scales of the healthy insects there were vast numbers of eggs which are most likely intended for over-wintering. It would be interesting to see if the eggs unprotected by the fungus covering overwinter as well as those beneath the fungus. This insect has a comparatively thin scale and it is possible that eggs protected only by the scale could not resist either prolonged desiccation or severe freezings. Before it can be said that the insects receive any definite benefit from the fungus in the way of protection a prolonged series of observations must be made in the field.

Since the fungus does not penetrate at all into the bark of the dogwood, it appears to be entirely dependent upon the insects for its food

supply, drawing this indirectly from the shrub through the parasitized insects.

This fungus (Dr. Dearness, coll., 3396) was examined by Burt (1916) and placed under *S. pseudopedicellatum* Burt (Mo. Bot. Gard. Herb., 43802). The two plants, however, are very distinct in a number of ways and are easily separated by a casual examination. In *S. pseudopedicellatum* Burt the subiculum is white throughout, the pillars are dark colored, long and straight, unbranched, narrow, and are extraordinarily distinct, as distinct as in any species of *Septobasidium*. These characters, together with the reproductive organs, will serve to distinguish *S. pseudopedicellatum* Burt from *S. Carestianum* Bres.

The present species is very close to *S. alni* Torrend. In color characters *S. Carestianum* and *S. alni* may be separated, but only after an examination of a large amount of material representing all stages of development. The color of *S. Carestianum* is usually a lighter shade of brown than is that of *S. alni*, often being cream-colored. In *S. alni* the margin is usually determinate and sometimes (especially in specimens on pecan) the new growth region is a very distinct yellowish clay color as contrasted with the older dark brown region of growth, whereas *S. Carestianum* usually has a more or less indeterminate margin and shows no distinct color zones. Another important point of distinction is in the way in which the hymenia are formed in the two plants. In *S. alni* the hymenium as a rule extends almost out to the margin of the subiculum and does not show gaps and irregularities as in *S. Carestianum* in which the hymenium is incompletely formed in a number of areas during the period of growth. Microscopically the two plants are different in the size of the hyphae of the pillars and top layer and the size and shape of the probasidia and the size of the basidia and spores.

This plant is also related to *S. filiforme* but may easily be separated from that plant by the coiled basidia in *S. filiforme* and the presence of the abundant delicate threads with brownish contents in the hymenial region in the latter plant. In *S. Carestianum* there may be found a few threads in the upper layer with dark contents. Such threads are much thicker than the threads found in the hymenium of *S. filiforme*.

This plant may be distinguished by the thin fructification, the peculiar marginal characters, and the pyriform and frequently very irregular probasidia.

Specimens examined:

Italy: Type (?), on branches of *Salix*, 1897, part in N. Y. Bot. Gard. Herb.

Location ?: On *Salix incana* Schrank with *Chionaspis salicis* (L.) Sign., Aug. 15, 1917, Otto Jaap, indent., part in U. S. D. A. Herb. (V. Höhnel, 820).

France: Epinay, on *Cornus sanguinea* with *Chionaspis salicis*, July, 1906, in Patouillard Herb., Harvard University, spores present, 3.8 x 13.8μ; *S. Carestianum* Bres. forma *Fraxini* Pat., on trunk of *Fraxinus excelsior*, October, 1909; shows more distinct pillars but otherwise agrees with type.

Canada: North of London, Ontario, on living limbs of *Cornus stolonifera*, collected by Dr. Dearness, 3396, Sept. 25, 1911, not in fertile condition, 9115; also July 10, 1929, 9116, fertile; August 23, 1929, 9117, no basidia found; November 11, 1929, 9118, not fertile; March 22, 1930, 9119, not fertile; Sept. 11, 1931, 9120, not fertile.

Brazil: Sao Leopoldo, Dec. 16, 1934, J. Rick, coll., in U. N. C. Herb., 9902, 9903.

Septobasidium alni Torrend. Broteria, Ser. Bot. **11**: 84. 1913.

Plates 2 and 21

Fungus body resupinate, growing in medium sized patches, 2–10 x 3–20 cm., often girdling the limbs. Surface inherently smooth in mature specimens, becoming wrinkled and cracked when old; color, when fresh but dry, cinnamon to Prout's brown or Saccardo's umber; much darker, about burnt umber, when wet. Margin of growing region irregular, sometimes byssoid, whitish, buff colored or sometimes yellowish. In section up to 400μ thick, usually composed of three regions: (1) the subiculum or lower layer which extends over the bark, very compact, about 30–65μ thick, composed of thin-walled, pale brown to nearly hyaline hyphae about 3μ thick; (2) the middle region composed of a very few, short, upright pillars between which are very wide spaces; pillars 40–100μ tall, often up to 175μ thick, sometimes much thicker and not rarely as thin as 20μ, composed of brownish hyphae about 4.2μ, thick, pillars branching out above and forming (3) the more or less papery top layer on the outer surface of which is formed the hymenium, top layer 200–250μ thick, composed of fairly densely packed, slightly branched and entangled hyphae which grow at a slight angle to the surface, hyphae deep brown in color except in the hymenial region, rather thick-walled, 3.5–4.2μ thick. Threads throughout with few septa and no clamp connections. Hymenial region very thin (in my specimens), composed of thin-walled, slightly branched, nearly hyaline threads, probasidial cells, and basidia. Probasidial cells globose to subglobose, sessile, 9–12μ thick before germinating, nearly hyaline and quite inconspicuous in the hymenium, probasidium sprouting into a long cylindrical basidium into which the probasidium empties its entire

contents, empty probasidial cell elongated ovoid or ellipsoid, 8.8–10 x 18–24μ, thick-walled (1.5–2μ), new probasidia often formed in the old empty probasidial cells, elongated. Basidium 5–5.4 x 50–60μ, becoming thrice septate, and thus four-celled, each cell giving rise to a sterigma about 8μ long. Spores (of No. 8325) 3.4–4.2 x 15.9–21μ, smooth, bent-elliptic, becoming thrice septate, at times seven times septate soon after shedding.

Associated with scale insects some of which are parasitized by irregular coils while others are not parasitized.

This species shows remarkable similarities to *S. Cavarae* Bres. The American material has been compared with type material lent to me by Sydow (Torrend, No. 68) and the two lots of material agree in most respects. The type material does not show any basidia or spores, but does show vast numbers of empty probasidial cells and a considerable number of probasidia growing up into the older, empty probasidial cells. I have found more or less the same condition in my material collected during late summer, fall or winter. I am convinced that Torrend mistook these probasidia for the basidia, since the measurements which he gives for the basidia agree with the size of the probasidia found so abundantly in his material. He does not mention the probasidia, but concerning the basidia he says, "at first globose, 10–12μ in diameter, at length ellipsoid, 3-septate, 20–25 x 7–9μ; spores not seen."

This species can be recognized by the thin fructification, by the more or less papery top layer, by the few, inconspicuous, short, scattered pillars, which, however, cannot be seen well unless the top layer is removed and turned over, in which case the pillars adhere to the top layer; and by the buff colored margin, contrasting strikingly with the brown older region (this color is conspicuous only at the end of the growing season—late summer and fall). One remarkable peculiarity of this species is the fact that new probasidia are often formed within the old empty probasidial cells. Such probasidia are present in large numbers in regions of old growth in the late summer and fall and if a specimen bearing such probasidia is kept in a damp chamber, the latter will germinate, forming basidia. Another peculiarity, in some specimens, is the presence of numerous clusters of green algal cells imbedded here and there in more or less regular order just below the upper surface of the fungus. Delicate fungal threads often surround some of the algal cells and seem at places to penetrate into the cells.

In typical specimens of this species the pillars arise in a row from the subiculum, at first about one millimeter behind the growing margin.

These grow upward and quickly branch out at the top, developing first into an umbrella-like structure with a very short, thick stalk and an exceedingly wide, flat covering. After the subiculum has grown out a third or half a centimeter from the first row of pillars, another row arises and develops in the same way. The tops of the pillars grow in a horizontal direction until their margins come together and fuse. In the hybrid described below growth may stop before the margins all come together, thus leaving irregular spaces several millimeters wide between the margins. This condition gives the fungus a peculiar flaky appearance as though the top layer were peeling off. In my collections the flaky appearance is commoner in the sweet gum specimens, though it is also found in the willow oak, hickory, and American holly specimens. This flaky appearance has not been noticed on specimens occurring on pecan. In some specimens pillars may be entirely lacking in certain regions.

Fairly common in eastern North Carolina, South Carolina, Georgia, and probably in states farther south.

Specimens examined:

Portugal: Type, on *Alnus*, Torrend, coll. (373 in N. Y. Bot. Gard. Herb. and 68 in Sydow Herbarium now in Upsala).

North Carolina: Near Beaufort, on *Liquidambar*, Aug. 4, 1929, J. N. Couch, coll., 8415, common.

South Carolina: St. Helena's Island, J. N. Couch, coll., on *Quercus nigra*, with *Aspidiotus osborni*, March 21, 1930, U. N. C., 8485; on *Quercus phellos*, with *A. osborni*, U. N. C., 8481; on *Magnolia virginiana*, with *Aspidiotus diffinis*, U. N. C., 8482; Springwood, on *Q. phellos*, with *Chrysomphalus obscurus* Comst., July 2, 1928, J. N. and A. B. Couch, colls., U. N. C., 8323; on *Liquidambar*, with *Aspidiotus* (*Cryptophyllaspis*) *liquidambaris* Kot., U. N. C., 8325; on *Ilex opaca*, with *Aspidiotus forbesi*, U. N. C., 8327; on *Hicoria*, with *Aspidiotus ancylus* Putn., 8324; near Clemson College, on *Hicoria pecan*, with *Aspidiotus ancylus* Putn., Feb. 20, 1930, Geo. M. Armstrong, coll., U. N. C., 8437, also Nov. 24, 1930, U. N. C., 8556.

Georgia: Barnesville, on *Hicoria pecan*, common, Oct. 14, 1930, B. B. Higgins, U. N. C., 8498, fertile.

Venezuela: Carabobo, Valencia, 430 meters, on *Citrus sinensis*, Chardon and Stelling, 806, August 6, 1932, also in U. N. C. Herb. and L. O. Overholts Herb.

Septobasidium alni var. **squamosum** n. var. Apparently a hybrid between *S. alni* and *S. castaneum*.

Plates 2 and 25

Fungus body resupinate, the patches of growth being intermediate in size between *S. alni* and *S. castaneum*. Color about Saccardo's umber, sometimes brown with a distinct grayish tinge (No. 8485). Margin determinate or indeterminate. Surface flaky, due to the incompletely formed top layer. The flakes, which form all the top layer present in this species, vary from about 1 up to several square mm., crowded and anastomosing or scattered with 1 or 2 mm. between each flake. In section the entire plant is exceedingly thin, the flakes papery thin. Pillars scarce, the flakes usually arising directly from the basal layer. Pillars when present short and thick. Probasidia formed over the surface of the flakes and also over the basal layer except beneath the flakes; spherical, 9–11.3μ thick; basidia 4–5 x 40–50μ, cylindrical, 4-celled (No. 8323). Spores as in *S. alni* except slightly smaller. Associated with scale insects, some of which are parasitized by irregular coils.

This hybrid form can easily be recognized by its brownish color, exceedingly thin structure, and the flaky nature of the upper layer. It occurs with *S. alni* and *S. castaneum* and is possibly a hybrid formed by the crossing of these two species. The forms belonging here were first segregated under *S. alni*.

Specimens examined:

South Carolina: Near Myrtle Beach, on *Liquidambar styraciflua*, common, August 29, 1931, 9087, 9088, 9089; St. Helena's Island, on *Liquidambar styraciflua*, March 21, 1930, J. N. Couch, coll., 8479; Springwood, on *Liquidambar styraciflua*, with *Aspidiotus* (*Cryptophyllaspis*) *liquidambaris* Kot., July 3, 1928, J. N. Couch, coll., 8325; also on *Hicoria* with *S. alni*, 8324.

Septobasidium lepidosaphis n. sp.

Plates 6 and 19

Fungus body resupinate, extending over the surface of the stem and leaves of *Citrus* sp., covering a relatively small area (6 sq. cm.) in my specimens. Carob or Van Dyke brown (Ridgway). Surface characteristically covered with numerous, erect, pointed spines, which may be 1.2 mm. high; spines usually anastomosing considerably; surface sometimes with a wefty or irregular honeycomb appearance. Margin usually indeterminate but sometimes distinct. In section composed

of two or three regions: (1) the subiculum which is very thin, 10–20μ thick, threads of subiculum 3–6.3μ thick, septate without clamp-connections but with much anastomosing between threads; (2) from the subiculum arise a tangled weft of hyphae or more frequently hyphae which unite to form thin pillars which in turn unite to form larger upright spines, spines up to 75μ thick, usually thinner, hyphae of spines 4.2–5μ thick, septate without clamp connections, usually straight and rarely branching. (3) In some specimens a third region may extend over the tops of the spines, forming an irregular hymenial layer. Probasidia formed over the marginal region of the subiculum and over the top layer if a top layer is formed, and rarely on the spines, spherical 8.4–12.6μ thick, usually about 9.5μ thick, wall hyaline and rather thin (in my material). (Along with the probasidia are numerous enlarged bladder cells or perhaps aborted probasidial cells); probasidia germinating to form an elongated, straight cylindrical or sometimes curved, 4-celled basidium, 4.2–6.3 x 31.5–46μ, usually about 5.4 x 35μ; sterigmata small, about 4.2μ long; spores strongly bent-elliptic, 3.2–4.2 x 10.9–13.8μ.

Associated with the purple scale insect (*Lepidosaphes beckii*), some of which are parasitized by irregular coils while others are unharmed by the fungus. The fungus passes through the vaginal pore of the parasitized insects.

This species is very distinct from any other one so far described and may easily be recognized by the brownish color, dense tall spines, the sometimes coiled basidia, and most striking of all characters—the fact that the probasidia and basidia are formed on the flat thin margin as well as on the top layer when a top layer is present.

If infection of the young occurs here by the bud cells which come from the spores as in *S. Burtii*, the fact that the latter are borne on the margin would facilitate the infection of young migratory insects which happened to crawl out over the margin as the spores were being formed.

Specimens examined:

Florida: Okeechobee, on *Citrus grandis* with *Lepidosaphes beckii*, Jan. 20, 1933, L. S. Light, coll., in Univ. of Florida Herb., 8933 and U. N. C. Herb., 9345; near Venus, on *Citrus aurantifolia*, March 23, 1933, R. B. Linger, coll., in Univ. of Fla. Herb., 9053, and U. N. C. Herb., 9363.

Brazil: Viçosa, Estado de Minas Gerais, on *Citrus* sp., June 10, 1929, A. S. Müller, coll., type, in Müller Herb., 43 (see Phytopathology **23**: 734–737. 1933) and U. N. C. Herb., 9721; Lagoa Grande, on native tree, June 24, 1934, A. S. Müller, coll., in Müller Herb., 831, and

U. N. C. Herb., 9961; also near Viçosa, on *Vernonia crotonoides*, July 10, 1934, A. S. Müller, 832, and U. N. C., 9962; also on *Mangifera indica*, A. S. Müller, 833, and U. N. C., 9963. Müller's collections also deposited in Cornell Univ. Herb.

Septobasidium Curtisii (B. and D.) Boedijn and Steinmann. Bull. Jardin Bot. Buit. **11** (3): 181. 1931.
Glenospora Curtisii Berkeley and Desmazières. Journ. R. Hort. Soc. **4**: 243. 1849.

Plate 5

Fungus resupinate, thin, growing in effused patches which often cover an area equal to 30 or 40 square centimeters. Surface nearly smooth in some specimens but more often dotted with minute areolations, considerably cracked in old specimens (in some specimens, especially those on oak, the surface is roughened by upright pillars of hyphae); usually black with a purplish tint (about plumbeous black of Ridgway) but often fuscous. Margin variable, sometimes thick, terminating abruptly and then concolorous with the main surface, usually thin during the growing season and of a lighter color than the main surface, whitish with a purplish sheen toward the outer edge, and sometimes indeterminate. Marginal region dotted with numerous patches of elevated hyphae which sometimes are star-shaped, umbrella-shaped, tent-shaped or shaped like an Eskimo hut. In section about 200–400μ thick, sometimes compact throughout but more often composed of three more or less distinct regions: (1) the subiculum which grows horizontally over the bark, very thin, hyphae of subiculum 4–5μ thick in marginal region with much anastomosing between threads; (2) the middle region which arises from the subiculum sometimes as short thick pillars, the threads of which quickly branch out to form the top layer; (3) top layer 60–300μ thick, the thickness depending upon the age, threads of top layer and pillars about 4μ thick; in young specimens composed of only one hymenial region while in old specimens the top layer may be stratified by the successive formation of several hymenial layers. Hymenium composed of probasidia and basidia. Probasidia formed during the fall and early winter (young, small, thin-walled Oct. 10, mature Dec. 10), germinating into the basidia during the spring and early summer; mature probasidia 10.8–16.8μ thick (most about 12μ thick), spherical, wall about 1.5μ thick, often with numerous minute furrows on the inner side which give the wall, in a section view, the appearance of being pitted; basidia 6.3–7.6μ thick by 62–70μ long, counting the stalk, straight, thickest in the middle, often breaking off from the probasidium and its stalk; stalk 10–20μ long; basidium becoming divided by three transverse walls into four cells, each cell sprouting a short pyramidal shaped sterigma, which is very peculiar in that, after the formation of the basidiospore, the sterigma remains full of protoplasm and then buds several

very minute sporidia; basidiospores hyaline, usually bent-elliptic, becoming once or thrice septate, 3–4.2 x 13–21μ, up to 29.4μ long. Conidia formed over the lower surface of the fungus, globose, borne in chains.

Associated with *Chionaspis sylvatica* Sanders, *C. gleditsiae* Sanders, *Chrysomphalus obscurus* Comst., and *Aspidiotus* sp. on a large variety of trees and shrubs, being perhaps the most widely distributed and commonest species in the United States, also reported from Java on tea by Boedijn and Steinmann.

The present species because of similar habitat and color may be confused with *S. Patouillardii* Burt. Burt's material of *S. Patouillardii* was collected on living branches of *Fraxinus*, *Liquidambar*, and *Nyssa*, which hosts I have found to be very common ones for the present species. Burt (1916) describes his plants as being "aniline-black at first, becoming fuscous in the herbarium," colors which agree with the present species. The two plants may be separated by gross and microscopic characters. *Septobasidium Patouillardii* Burt always shows a distinct differentiation into three layers, the top layer being supported by pillars. In the present species the layered condition is often quite indistinct and the plant is never distinctly three-layered throughout. In probasidial and basidial characters the two plants are quite distinct. In *S. Patouillardii* Burt the probasidia are small and elongated in shape; in the present species they are large, distinct, thick-walled, and globose. In the former the probasidial cell elongates to form a two-celled basidium, the probasidial cell therefore does not persist after the formation of the basidium; while in the present species the four-celled basidium sprouts from the probasidial cell, the latter persisting for a long time as an empty cell after the basidium has matured.

The fungus-insect combination causes considerable damage to certain trees and shrubs, particularly species of *Fraxinus* and *Nyssa*. The commonest type of injury shows itself as a cracking of the bark with a marked hypertrophy of the underlying tissue and sometimes the injury may show itself in the form of witches' brooms.

Specimens examined:

New Jersey: Newfield, on *Nyssa multiflora*, winter 1874, J. B. Ellis, coll., probasidia abundant, 10–14μ thick, many 12.6μ, no basidia. Associated with *Chionaspis* sp., many of which are not parasitized and are giving birth to young. Typical (In U. S. D. A. Herb., De Thümen, Mycotheca Universalis, 292).

Maryland: Hyattsville, on *Nyssa*, F. L. Scribner, coll. Typical.

Virginia: Clarendon, on living limbs of *Nyssa sylvatica*, April 16, 1923, J. R. Weir and W. W. Diehl, colls. Two other collections from Va.; also near Roanoke, April 21, 1931, C. L. Shear, coll; (all in U. S. D. A. Herb.)

North Carolina: Exceedingly common from mountains to coast, represented by 60 collections, the only species common in mountains, J. N. Couch, coll; also collected by W. W. Diehl, on *Nyssa*, by F. L. Stevens on *Juglans*, and by P. O. Schallert (U. S. D. A. Herb.).

South Carolina: Common, represented by 14 collections.

Georgia: Near Vaughan, on *Ilex decidua*, Nov. 3, 1933, B. B. Higgins, fertile, 9336; near Valdosta on *Nyssa*, 9300; near Darien, Ravenel, coll., 333, probasidia very abundant, 10.5–13μ thick, often slightly rough, no basidia seen, typical; also on *Carpinus*, (U. S. D. A. Herb.); near Cairo, on *Pyrus communis*, Ogara and Worth, colls., Feb. 2, 1903 (U. S. D. A. Herb.); near Fort Valley, on *Viburnum*, Jan. 19, 1922; also March 18, 1922, J. C. Dunegan, coll. (in L. O. Overholts Herb., 8114, also in U. S. D. A. Herb.).

Florida: Common as far south as Sebring. Near Gainesville, on *Fraxinus*, October 4, 1933, G. F. Weber, coll. (Univ. Fla. Herb., 9412. Several collections, on *Nyssa*, J. N. Couch; also on deciduous tree, Calkins, coll., winter of 1886 (U. S. D. A. Herb.).

Mississippi: Pascagoula, very common on *Nyssa*, and *Fraxinus*, J. N. Couch.

Alabama: Near Auburn, on *Nyssa*, F. S. Earle and C. F. Baker, colls., 2240, Jan. 16, 1897, typical; also on *Nyssa sylvatica*, Dec. 5, 1922, L. E. Miles, coll. (both in U. S. D. A. Herb.).

Louisiana: On *Magnolia* sp., Langlois, coll., Nov. 4, 1888, many empty probasidia, no basidia; near Pointe a la Hache, on *Carpinus*, April 20, 1888, Langlois, coll., many probasidia, no basidia; on *Gleditsia triacanthos*, Jan. 5 and 6, 1886, Langlois, coll., material abundant, probasidia 10–13μ, some minutely spiny, no basidia seen (Langlois, 179); near Monroe, on *Nyssa sylvatica*, Jan. 30, 1928, E. L. Dennison, coll. (all in U. S. D. A. Herb.); also near Opalousas, on *Carpinus* (?), April 16, 1932, C. L. Shear, coll., fertile, the best fruiting material I have yet seen of this species, probasidia 12–16.8μ thick, spores up to 30μ long (in U. S. D. A. Herb.); near Madisonville, on *Nyssa*, Nov. 6, 1932, C. A. Brown, 553, also in U. N. C. Herb., 9953; near New Orleans, very common on *Nyssa* and *Fraxinus*, Dec. 31, 1931, J. N. Couch, coll.

Arkansas: Near Little Rock, on *Gleditsia triacanthos*, 9374, and *Quercus phellos*, 9375, April 12, 1933, D. V. Baxter, coll. The collection on *Gleditsia* is not typical, having a much better developed top layer than usual.

Guatemala: On angiosperm tree, Dec. 28, 1906, W. A. Kellerman, coll., pillars very abundant, about one millimeter tall, hymenium forming a smooth surface over tops of pillars and hence not typical, probasidia very abundant, spherical, 8.4–12.6μ, most about 9μ thick, color and wall characters as in Chapel Hill and Ravenel plants, basidia not seen. Before positive determination can be made, basidia should be studied (in U. S. D. A. Herb.).

Guadalupe: Near San José, on *Erythrina*, May 1915, Condert, coll., in Patouillard Herb. Harvard Univ., with *S. Leprieurii* (Mont.) Pat. This material is much like the above collection from Guatemala.

Java: Marywattie Estate, on *Thea*, July 1930, Steinmann, coll. (Herb. Hort. Bot. Bog., 11821, also in U. N. C. Herbarium), probasidia present, no basidia, many upright spines, no smooth hymenial surface.

Septobasidium Cokeri n. sp.

Plates 17 and 39

Fungus body resupinate, covering an area of several square centimeters (up to 15 cm. in diameter) on the bark of a variety of trees and shrubs. Typically pure white throughout when fresh and frequently retaining the pure whiteness in the herbarium, sometimes creamy on the surface and becoming brown upon aging, sometimes becoming blackish in the older parts. Margin determinate. Surface smooth and usually free from cracks except in old specimens. In section 0.6–1.3 mm. thick, composed of three distinct layers, frequently stratose: (1) the subiculum which extends over the bark 40–70μ thick, threads of subiculum 3–3.7μ thick; (2) the pillars, which arise from the subiculum, arising singly or sometimes in tufts, each pillar with a circlet of short threads at its base, these threads encrusted with crystals; 18–185 x 370–510μ, composed of much septate threads sometimes constricted at the septa and frequently thick-walled, 4–5.5μ thick. The pillars often arise in concentric rows on the margin, each row being about 0.25 mm. apart. In the older parts this concentric arrangement of the pillars is not evident. Threads of pillars branching above to form (3) the top layer over which the hymenium is formed, 70–148μ thick; threads 4–5.9μ thick, frequently thick-walled, with a very small lumen and sometimes constricted at septa. Hymenium 25–50μ thick, composed of probasidia and hyaline paraphyses. Probasidia globose, subglobose, or more usually pyriform, 10 x 11–16μ, sometimes subtended by one or more

large cells, probasidial wall often considerably thickened, up to about 2μ thick. Threads in hymenium 2–3μ thick, recurved but not wavy and of more or less even diameter throughout. Basidia long-cylindrical or sometimes curved, 4.4–6.2 x 40–55μ, 4-celled and with a long stalk which remains attached to the empty probasidial cell; sterigmata lateral, small, about 5μ long. Spores 3–3.7 x 14.8–22.4μ, bent-elliptic.

Associated with scale insects some of which are parasitized by irregular coils, while others are unharmed by the fungus. Most commonly found on *Quercus* spp., also on several other trees and shrubs. Distributed from New Jersey southwards to Florida. Frequently found with typical *S. pseudopedicellatum*, *S. Mariani*, *S. Burtii*, *S. Curtisii*, and *S. apiculatum*.

This species has been included in *S. pseudopedicellatum* by Burt (1916) and Coker (1920) but may be distinguished as a rule by its almost snow white or creamy color throughout. This whiteness is very distinctive and by marking certain specimens and keeping them under observation through the seasons it has been found that the whiteness is not a mere seasonal condition but persists throughout the year. The very distinct unbranched pillars, which in the marginal region arise frequently in concentric rows, the pillars in each row often being so close to each other as to form a solid phalanx, are also characteristic. Even in older specimens the older surfaces of which are buffy or brownish in color the pillars will always be whitish or light buff and never dark brown as in *S. pseudopedicellatum* Burt. Another distinguishing character of this fungus is in the hyphae. The subhymenial hyphae are frequently thick-walled, constricted at the septa and with small lumina. Such hyphae resemble those of *S. apiculatum* n. sp. with which this form sometimes occurs. The basidia and spores are also smaller than those in *S. pseudopedicellatum*.

Specimens examined:

New Jersey: Newfield, on living saplings of *Quercus tinctoria*, Jan. 1900, J. B. Ellis Herb., also in Farlow Herbarium. Burt included this under *S. pseudopedicellatum* but wrote on label: "This does not have exactly the structure of *S. pseudopedicellatum*. Perhaps it is weathering that has caused change."

Virginia: Mecklenburg Co., on *Cornus florida* with *S. filiforme*, July 13, 1927, J. N. Couch, coll., 8179.

North Carolina: Chapel Hill, on *Quercus rubra*, 8439, 8440, 8441, 9108, 9326, 9385, 10004, type; on *Quercus velutina*, 10000; on *Quercus*

palustris, 8303A, 8563; on *Quercus phellos*, 8391, 9224; on *Quercus montana*, 9102; on *Cornus florida*, 8394, fertile; also on *Cornus amomum*; on *Fagus grandifolia*, 8187; on *Acer negundo*, 9072, 9109; Cary, on *Quercus phellos*, John R. Raper, coll., 9430; Pasquotank Co., on *Hicoria aquatica*, April 4, 1933, Willard Hewitt, coll., fertile, 9367; near Magnolia, on *Quercus*, Jan. 1931, A. C. Mathews, coll., 9966. Beautiful specimens.

Florida: Near McClenny, on *Quercus* sp., Jan. 18, 1933, W. L. Kersey, coll., Univ. Fla. Herb., 8923, also U. N. C. Herb., 9344.

Septobasidium leprosum n. sp.

Plates 12 and 29

Fungus body resupinate, forming rather small irregular patches on the bark of the younger limbs of living trees; usually not more than two or three centimeters in diameter, rarely as much as four or five; white. Surface irregular in young specimens, the marginal region dotted with numerous, small (about 1 mm. in diameter) apparently isolated patches of growth, marked in the older regions by numerous sinuous, anastomosing channels; as growth proceeds these channels are more or less closed so that numerous unconnected round or irregular pin holes are left in the surface; in the still older regions of growth the pin holes are closed. On *Ilex* and *Hicoria* the top layer never becomes a smooth continuous surface but remains in the form of small patches 1 or 2 mm. wide (hence the name *leprosum*). Margin indeterminate. In section exceedingly thin, 60–130μ thick, rather indistinctly differentiated into layers or regions except where there are chambers or tunnels. In such regions composed of a very thin subiculum about 12–20μ thick, from which arise a few thick (usually about 65μ), short (about 45μ tall) pillars which partly support the top layer, the roof of the chambers or tunnels; top layer 40–50μ thick. Threads septate, without clamp connections, hyaline; about 4.2μ thick in subiculum, with thickened walls, threads thinner in hymenial region, 2.1–2.5μ thick, with thin walls. Hymenium formed over the entire surface, composed of probasidia and basidia and simple, slender threads. Probasidia globose or slightly pyriform, 10–11 x 10–13.8μ, hyaline, with slightly thickened wall; formed during the early winter and germinating in the early spring to form a long, cylindrical, four-celled basidium. Probasidium becoming entirely empty during germination and persisting as an empty sac. Basidium 6–6.5 x 50–56μ, straight, sprouting a short sterigma from each of the four cells and normally bearing four spores. Spores white, smooth, bent-elliptic, 4.2–5 x 12.6–15μ.

Symbiotically associated with scale insects, some of which are parasitized by irregular, gnarled coils of hyphae and others of which are not parasitized.

This species can be easily recognized by its white color, very thin structure, by the irregular holes in the plant body, and by the numerous, small, apparently isolated, patches of growth around the margin.

This plant shows a remarkable adaptation to a symbiotic relation with scale insects. In the plant body there are numerous chambers connected by tunnels which open to the exterior through the irregular holes described above. The floor of these chambers and tunnels is formed by the thin subiculum and the roof is formed of a thin but compact mat of threads which bear the hymenium. The roof of each chamber is supported by one or two thick short pillars. This adaptation can be better seen if the development of the fungus is followed. If a young specimen or the margin of an old specimen is examined one sees numerous, small, apparently isolated, patches of growth. If these patches are examined under a dissecting microscope, they are seen to resemble the snow huts of Esquimaux in shape. These little huts arise by upgrowths of hyphae from the subiculum. As growth proceeds the tips of the hyphae bend over toward each other, finally coming in contact and forming an arch. These little huts are about a millimeter apart. As development goes on, the roofs of the huts branch out and grow toward each other until the space between the huts is closed, except for numerous tunnels which connect the huts with each other, and connect the older huts with the newer ones, and thence with the exterior.

These huts are the homes of the scale insects. The houses containing parasitized insects finally become completely closed while the houses of the healthy insects remain open, communicating with the exterior through the tunnels. As the young hatch out they crawl out to the new houses and settle down there.

This species is commoner than my collection data indicate. It is so inconspicuous as to be easily passed over.

Specimens examined:

Virginia: Mecklenburg Co., on *Cornus florida* with *S. filiforme*, 9179.

North Carolina: Chapel Hill, on *Ilex decidua*, several collections from same tree, 9150, 9352, 9372, type; on *Cornus amomum*, Jan. 20, 1928, J. N. Couch, coll., 8302A; on *Fraxinus* sp., March 8, 1929, P. A. Rhodes, coll., 8387; on *Crataegus* sp., Dec. 20, 1931, J. N. Couch, coll., 9149.

South Carolina: Near Charleston, on *Cornus florida*, March 19, 1930, J. N. Couch, coll., 8463; Springwood, on *Hicoria*, July 2, 1928, J. N. Couch, coll., 8324a.

Louisiana: Near Baton Rouge, on *Ilex decidua*, Dec. 31, 1931, J. N. Couch, coll., 9171.

Septobasidium fumigatum Burt. Ann. Mo. Bot. Gard. **3**: 332. 1916.

Plates 4 and 23

Fungus body resupinate, covering extensive areas on the trunks and limbs of trees, sometimes extending from the base nearly to the top of a tree; mummy brown or snuff brown, or sepia (on maple) to nearly black (on *Cornus*) where the hymenium has not been formed. Hymenium light to dark gray (pallid mouse gray or light mouse gray to mouse gray of Ridgway), contrasting strikingly with the brown where the hymenium has not formed. Hymenial surface smooth except for a few cracks, sometimes with numerous holes 0.3–0.5 mm. in diameter; surface without hymenium characteristically spongy or alveolate. Margin determinate or indeterminate, sometimes with fine rhizomorphs. In section 600–1400μ thick, usually about 1 mm. thick, composed of loosely interwoven, branched, septate, non-nodose hyphae, 3.8–4μ thick, which arise from the substratum to hymenial region, not differentiated into pillars. Hymenium 33–50μ thick, composed of once or twice coiled, thin-walled, hyaline threads about 3μ thick, and probasidia and basidia. Probasidia spherical to subspherical, with a hyaline wall when young, brownish and punctate when mature, 12–16μ in the greatest dimension, sprouting and emptying their entire contents to form club-shaped basidia. Basidia distinctly thicker at the distal end, four-celled when mature, 7.5–9.2 x 40–56μ, each cell giving rise to a sterigma (about 8–10μ long) on the end of which is borne a spore; spores bent-elliptic, 4.6–8 $\times$ 15–21μ, most 6.3 x 16μ (no. 8458).

Distinguished by the mouse or pale mouse gray color of the hymenium and the sepia, mummy, or snuff brown of the vegetative part, the lack of pillars, the spongy structure of vegetative part, the coiled threads in the hymenium, and basidia which are distinctly enlarged in the distal part. Related to *S. alveolatum* in vegetative structure but may be separated from that species by the smaller reproductive structures and the straight basidium in *S. fumigatum*.

Associated with *A. tenebricosus* and *Aspidiotus* sp., some of which are parasitized by spindle-shaped hyphae connected by fine threads. These hyphae are of two sorts: the main threads composed of long cells from which arise coiled or twisted hyphae composed of shorter cells. Vast numbers of the insects of both species are free from parasitism, carrying on their life histories year after year beneath the thick spongy mass of fungal tissue.

This is one of the commonest species from South Carolina southward

into Florida, being most frequently found on *Acer rubrum*. In Highlands Hammock near Sebring, Fla., it was by far the commonest species, occurring with the scale insects on practically every red maple tree in the hammock. I found one tree of *Acer rubrum* with a trunk three feet in diameter the main trunk of which was heavily infected. Frequently the stems of smaller trees may be almost completely clothed by the fungus for several feet. Such heavily infected trees were always unhealthy, showing large numbers of dead limbs in infected areas. Also occurs on mulberry, *Cornus*, and *Tilia*. Extending northward as far as South Carolina and westward as far as Louisiana.

I have studied type material (Mo. Bot. Garden Herb., 43822) collected on the trunk of living *Acer rubrum*, Santee River, near Gourdin, South Carolina, and find that my material agrees with the type. It should be pointed out, however, that in Burt's drawings of the type, figure 12, he fails to show the probasidial cell at the base of the basidium. Such drawings along with Burt's statement in the text convey the impression that the basidium is formed by the elongation of the probasidial cell and that the latter does not persist after the formation of the basidium. An examination of the type material shows that the probasidial cell becomes empty during the formation of the basidium, the contents of the former passing into the latter. The probasidium usually persists as an empty cell at the base of the basidium though sometimes it may collapse, but even then can be made out.

Specimens examined:

South Carolina: Type, Gourdin, on *Acer rubrum*, Nov. 4, 1914, C. J. Humphrey, coll., in Mo. Bot. Gard. Herb., 43822, Humphrey Herb., 2588, and Farlow Herb.; near Charleston, on *Acer rubrum*, abundant, March 19, 1930, J. N. Couch, coll., 8458, fertile; near Myrtle Beach, on *Acer floridanum*, August 29, 1931, J. N. Couch, coll., 9098; near Jacksonboro, on *Acer rubrum*, J. N. Couch, coll., 8476.

Georgia: Near Valdosta, on *Acer* sp?, March 17, 1932, J. N. Couch, 9297 and 9301.

Florida: Near Brooksville, on *Tilia* sp., Feb. 1922, J. A. Stevenson, 1641, in U. S. D. A. Herb., det. by E. A. Burt; also on *Acer*, J. A. Stevenson, 1673, in U. S. D. A. Herb., det. by J. R. Wier; near Sebring, Highlands Hammock, on *Acer rubrum*, March 14, 1932, J. N. Couch, coll., 9261, 9255, 9260, 9269, fertile; also on mulberry-like plant with white latex, 9275; also on *Cornus amomum* and *C. florida*, 9267 and 9267a.

Louisiana: East Baton Rouge parish, on *Acer rubrum*, March 19, 1932, C. A. Brown, 339, and U. N. C. Herb., 9964; near New Orleans on *Cornus amomum*, Dec. 31, 1931, J. N. Couch, coll., 9158, fertile.

Septobasidium cremeum n. sp.

Plates 12 and 31

Fungus body resupinate, closely adherent to the bark, forming areas as much as 10 x 10 cm. Younger areas light buff, older regions cinnamon-brown. Surface at first smooth, becoming cracked into small irregular areas as the plant ages. Margin very irregular, usually indeterminate. In section up to 225μ thick, usually about 210μ thick in well developed specimens, composed of three layers except in the marginal region: (1) subiculum usually very thin, up to 33μ thick, composed of hyaline, septate, non-nodose, hyphae; (2) middle layer composed of very short pillars; (3) top layer 60–130μ thick. Hymenium about 35–45μ thick, hyaline in color and hence sharply distinct from the lower part of the top layer which is brownish, threads of hymenium 2.2–3.5μ thick, colorless, densely packed, branched, coiled, and entangled. Threads of context and pillars 3.8–4.2μ thick, septate without clamp-connections, brownish under microscope. On the margin the hymenium may sometimes be developed not only on the top layer but also over the subiculum. Probasidia subglobose, about 8–9μ thick, the thread which bears the probasidium may be attached to it at the side or even top (i.e. the end toward the surface), as well as at the bottom; basidia usually coiled, 4.2–5 x 35–40μ, divided into four cells at maturity, each of which may give rise to a very long sterigma and bear a spore. Spores bent-elliptic, 3.8–5 x 11.5–16.8μ, not becoming septate on the slide.

Symbiotically associated with *Aspidiotus* (*Cryptophyllaspis*) *liquidambaris* Kot., some of which are parasitized by irregularly coiled hyphae, while others are not parasitized. The coiled hyphae, or haustoria, of the fungus connect with the main body of the fungus by means of hyphae which pass through the insect's derm by the mouth. These hyphae do not appear to interfere with the sucking operations of the insect, for the insect, though it may become heavily parasitized continues to live and suck the plant juice. The insects which are not parasitized reproduce young and carry on the life of the insects.

This species may be easily overlooked because of its inconspicuous color and thinness. It is related to *S. alni* and some of my specimens strikingly resemble that plant in color, in marginal characters, and in the pillars. The present species generally lacks the rich deep brown color of *S. alni*, being usually much lighter in color. It may also be

distinguished from *S. alni* by the coiled hyphae in the hymenium and the coiled basidia.

It is possible that the present species is a hybrid between *S. alni* and *S. tenue*.

Specimens examined:

Florida: Near Jacksonville, on *Liquidambar styraciflua*, with nearly black variety of *S. Burtii*, *S. sinuosum*, *S. castaneum*, *S. alni* and *S. tenue*, March 11, 1932, J. N. Couch, coll., type in U. N. C. Herb., 9232; La Cross, on *Ilex glabra* with *Aspidiotus juglans-regiae*, May 1, 1933, Geo. F. Weber, coll., in Univ. Fla. Herb., 9188, and U. N. C. Herb., 9395.

Septobasidium Sydowii n. sp.

Plates 5 and 30

Fungus body resupinate, forming circular patches up to 5 cm. in width. Chestnut brown or darker in the older regions, light grayish brown in the younger or fruiting regions. Surface smooth near the margin over a zone about 6–8 mm. wide, the rest of the surface conspicuously cut up by many deep fissures which are up to 1 mm. wide. Margin sharply determinate, with a minutely scalloped appearance caused by minute holes which lead back into short tunnels in the tissue of the fungus. In section about 1 mm. thick, very compact and hard, up to about 1.4 mm. thick, differentiated into context and hymenial regions. Context faintly stratose, composed of densely packed, entangled, rather sparingly branched threads which have mostly a vertical direction. Threads deep brown under microscope, thick-walled, rarely septate, without clamp-connections, 3.6–5μ, mostly 4.2μ thick. Hymenium 90–115μ thick, stratose, light colored and thus distinct in color from the context, threads vertical, thin-walled, collapsing easily, about 2.8–3.5μ thick; probasidia subglobose or ovoid, 9–10.5 x 13–15μ, germinating to form a once coiled basidium, collapsing soon after basidia are formed. Basidia about 6–7 x 30–40μ, 4-celled, sterigmata about 6–10μ long. Spores about 3.8–4.3 x 15.5–20μ, bent-elliptic, sometimes somewhat S-shaped, becoming thrice septate.

Symbiotically associated with scale insects, some of which are parasitized by irregularly coiled haustoria while others are free from fungal infection.

The specimens from Texas are light grayish brown and the fissures run out to the margin. The margin also differs from that in the Philippine material in showing short pillars or tufts of threads. The surfaces

of the two plants are cracked in the same way and the microscopic characters of hymenium, probasidia, basidia and spores agree.

This species may readily be distinguished from all other species of *Septobasidium* which I have studied by the peculiar cracked surface. The fungus has the appearance suggesting a miniature bit of baked, finely cracked clay.

The fungus-insect relationship is obviously a very interesting one. Numerous healthy (i.e. uninfected by the fungus) adult insects were found partly buried in the cracks, the posterior part of the ventral and dorsal scales projecting up through the fissures, the scales reminding one of the bivalved shell of an oyster. These adults contained many young and, judging by the widely opened condition of the genital pore, were in the act of giving birth to young. In the tunnels near the margin many dried up, but non-parasitized young were found and farther back in the tunnels there were half grown insects. A considerable number of insects were infected, and such insects were always completely covered by the fungus.

This fungus was first recognized as a new species by Dr. Sydow and turned over to me for study. I take great pleasure in naming it in his honor.

Specimens examined:

Philippine Islands: Province of Sorsogon, on *Pterocarpus*, Elmer, coll., 14820. Type.

Texas: Near Austin, on *Ulmus crassifolia*, Sept. 7, 1934, J. J. Taubenhaus, coll., U. S. D. A. Herb. and U. N. C. Herb., 9868.

Septobasidium taxodii n. sp.

Plate 42

Fungus body exceedingly thin, forming resupinate crusts on the bark of young twigs of *Taxodium*. Dirty Mars brown in color. Margin indeterminate. Surface usually roughened by cracks in the bark, or sponge-like under a lens where the fungus overgrows insects. In section about 100–250μ thick, not divided into strata and without a distinct subiculum. Hyphae penetrating into and in between the dead cells of the outer bark. External threads densely entangled, 2.1–4.2μ thick, brownish, septate without clamp connections, branched, frequently recurved in the distal part. Probasidia 10–12.6μ thick, spherical, giving rise to a coiled (often helically) 4-celled basidium, 5–6.3 x 33–40μ (the coil about 16μ across). Probasidium remaining as an empty cell after the basidium has been formed. Sterigmata 5–6μ long on the distal cells. Spores not certainly seen.

Associated with *Aspidiotus forbesi* Johnson on *Taxodium distichum*. Many of the insects are parasitized by irregular coils, the fungus passing through the insect's body wall at the vagina and anus. Occurring with *S. pseudopedicellatum* Burt and *S. Mariani* Bres.

Easily overlooked because of its thinness and inconspicuous brownish color. Its thin structure, brownish color, and coiled basidia distinguish it from most other species of *Septobasidium*.

Specimens examined:

Louisiana: Opelousas, on *Taxodium distichum*, April 16, 1932, P. R. Miller, coll., type in U. S. D. A. Herb. and U. N. C. Herb., 9938.

Septobasidium filiforme n. sp.

Plates 16 and 32

Fungus body perennial, resupinate, effused, occurring in patches of varying size up to 20 cm. long by 5 cm. wide. Color very variable, the young margin white, which is quite striking and conspicuous when fresh or damp; older regions pale buff in comparatively young specimens, becoming wood brown to deep buffy brown or army brown or natal brown, sometimes with a dusky purple tint; color fading considerably upon drying, surface usually becoming cracked after maturity into irregular patches about 1 cm. wide; the cracked edges often curling back somewhat and exposing the whitish subiculum; surface, except for cracks, very smooth. Whitish marginal region about 1–8 mm. wide, composed of young, undeveloped hymenium from beneath which a narrow border of the subiculum grows. Margin of subiculum often speckled with minute white dots,—the young pillars. In section 350–500μ thick in young specimens, up to 800 to 1000μ thick in old specimens, usually composed of three layers; in old specimens composed of a number of layers due to the annual formation of new pillars and an hymenium directly on top of the hymenium of the previous year: (1) the subiculum, which runs over the surface of the bark, white, 20–50μ thick; threads of subiculum hyaline under microscope, thin-walled, 2–3.2μ thick, septate without clamp connections; (2) the region of more or less vertical hyphae which arise from the subiculum and may adhere together to form the supporting pillars for the hymenium or may pass into the hymenium without forming the pillars; threads of this middle region 3.2–4.4μ thick, branched when not forming pillars, but threads of pillars sparingly branched, thick-walled and rarely septate; pillars very variable in diameter, composed of compactly arranged threads for only about one-third the distance between their base and hymenium, distance between subiculum and top layer quite variable (150–400μ); (3) hymenium thin, 42–60μ, rarely up to 90μ thick, composed of probasidia and basidia in various stages of development and hyaline, slightly bent

threads about 3μ thick and numerous conspicuous narrow threads, with deep brown contents, which usually break up into pieces of irregular length; probasidia pyriform, borne laterally, 7.7–11.8 x 14–23μ, sprouting a long narrow twisted and often coiled basidium 4–5 x 28–40μ. Basidium usually 4-celled, of which only the first three cells form spores; not rarely 3-celled or only 2-celled. Sterigmata very long, 20–30μ, partially or completely collapsing after the spores are formed. Spores hyaline, bent-elliptic, narrowed at the mucro end, 3.4–4 x 13–21μ.

Symbiotically associated with scale insects, some of which are parasitized by irregular coils, while others are left unharmed. The scale insects are parasitized through the anus and sometimes through both the anus and the genital opening. Through these openings a bundle of brown, thick-walled threads pass and within the insect these branch out into hyaline, thin-walled threads from which arise enormous clusters of the coiled haustorial threads.

Abundant on a large variety of trees and shrubs, but easily overlooked because of its comparatively small size. This species has been labelled in our earlier collections as *S. pseudopedicellatum* but can easily be separated from that form. Distinguished by the wide whitish margin contrasting with the much darker brownish color of the older regions; by its whitish subiculum, exposed in old specimens by the cracking of the upper layers. In microscopic structure it may be distinguished by the pyriform probasidial cells, by the peculiarly twisted or coiled basidia and *above all by the narrow threads with deep brown contents which break up into rods that adhere end to end.*

Specimens examined:

Virginia: Mecklenburg Co., on *Cornus florida* and *Liquidambar styraciflua*, July 13, 1927, J. N. Couch, coll., 9179, type, with *S. apiculatum* n. sp. and *S. Mariani*.

North Carolina: Chapel Hill, on *Alnus rugosa*, Jan. 24, 1920, J. N. Couch, coll., 4015, with *S. pseudopedicellatum*; on *Ligustrum chinensis*, Jan. 9, 1920, J. N. Couch, coll., 3923; on *Cercis canadensis*, Oct. 22, 1927, J. N. Couch, coll., 8273, very common; on *Ceanothus americanus*, also on *Hicoria* sp., October 20, 1927, J. N. Couch and W. L Hunt, colls., 8263; on *Pyrus japonica*, 8446, 9077; on *Crataegus Marshallii*, 8290; on *Syringa vulgaris*, 9106; on *Acer Negundo*, 9105; on *Carpinus caroliniana*, with *S. Mariani*, and *S. apiculatum* n. sp., 3924, also 8190, 8237, 8291; on *Cornus amomum*, 8388, 8558, 9104; on *Cornus florida*, 8272, 8349, 9107, 9432; near Raleigh, on *Cornus florida*, May 15, 1929, B. B. Fulton, coll., 8409.

Septobasidium sp. Hybrid form between typical *S. pseudopedicellatum* and *S. Schweinitzii*.

Plates 13 and 35

I have found several cases of hybridization between *S. Schweinitzii* and *S. pseudopedicellatum*. In collection No. 8319 on ash from Lynch's River bottom, S. C., we found an American ash tree mottled with *Septobasidium* from the base to the ends of the branches. Typical *S. pseudopedicellatum*, *S. Schweinitzii*, *S. Patouillardii*, and *S. leprosum* were present, the first three being the more abundant. The *S. pseudopedicellatum* and *S. Schweinitzii* were hybridizing. The typical *S. pseudopedicellatum* had a buffy to dark brownish surface, a whitish subiculum and long, distinct, individual pillars on the margin and between the upper and lower layers. The *S. Schweinitzii* material was not exactly typical, being lighter colored and with the sterile upright threads in the hymenium more wavy than typical. The margin of the subiculum showed the typical tent-like structures rather than upright pillars. The *S. pseudopedicellatum* was about twice as thick as the *S. Schweinitzii* and hence even ignoring the color and marginal characters it was possible easily to distinguish the two species. In a number of places on the bark the two species were growing in contact along their contiguous margins but in such pieces one could easily tell where one species ended and the other began although the margins were apparently in intimate contact. In such specimens the vegetative and reproductive structures were apparently unaffected.

In a large number of cases the two species were growing together, forming a new type of growth which combined the characters of both. Such organisms were distinct enough from both parents in vegetative and reproductive characters to justify their being described as a new species. I am considering this, however, as a hybrid form between *S. pseudopedicellatum* and *S. Schweinitzii*.

The hybrid form varies from a few millimeters in diameter to several centimeters and is about as thick as typical *S. Schweinitzii*. Color a dirty washed out buff. Marginal subiculum pale purplish and with both pillars and upright hyphae, each group of which is arranged at first in a plate with the outline of an incomplete ellipse. The sides of the plate come together above forming a miniature tent, the open part of which is always directed toward the older part of the fungus, these tent-like structures being typical of *S. Schweinitzii*. The "tents" and pillars are not scattered irregularly but a row of "tents" alternates with rows of pillars. Hymenium hyaline, in some specimens composed of much

twisted upright threads and probasidia and basidia. In some specimens the hybrid hymenium may be formed over the old hymenium of *S. Schweinitzii*, the hybrid threads apparently coming through the old layer of *S. Schweinitzii*. Other specimens have been seen in which the hymenium may show a resemblance in vegetative characters to *S. pseudopedicellatum*. Still other types of variation in the vegetative structure of the hymenium occur in other specimens. Probasidia spherical or subspherical, 8.4–12.6μ, averaging about 10μ thick (12 measurements), collapsing after emptying. Basidium 4.2–5.8 x 32–41μ, coiled, 4-celled, sterigmata about 3μ thick by 12μ long, usually straight, but sometimes coiled or twisted. Spores not seen.

I am unable to say whether these hybrids are formed by the grafting of the vegetative parts or by some kind of fusion of reproductive cells (bud cells from the spores). From studies on *S. retiforme* it seems very probable that hybrids are formed as follows: A scale insect hatches out beneath *S. pseudopedicellatum* or *S. Schweinitzii* and accidentally picks up the spores on its body and thus becomes infected. It now crawls away from the *S. pseudopedicellatum* out on the bark and finally settles down beneath a colony of *S. Schweinitzii*. The infecting cells of the fungus grow within the insect, as it develops, and eventually after the insect has moulted the last time the fungal threads of the *S. pseudopedicellatum* grow out through the anal or vaginal pore and anastomose with the threads of *S. Schweinitzii*, and thus the *S. pseudopedicellatum* is grafted onto the *S. Schweinitzii*. The course of events may proceed in exactly the opposite direction, i.e.: the insects may become infected with the spores of *S. Schweinitzii* and crawl away and settle down beneath *S. pseudopedicellatum*, etc.

Septobasidium Schweinitzii Burt. Ann. Mo. Bot. Gard. **3**: 324. 1916.

Plates 11, 15 and 33

Fungus body perennial, resupinate, forming isolated or confluent patches growing over the surface of the bark, covering areas of a few to 15 or more sq. cm. Color quite variable, usually brownish with a purplish tint (benzo brown, or Van Dyke brown, or light cinnamon brown). Surface velvety, not glabrous, often minutely warted, sometimes considerably cracked in old specimens. Margin determinate, whitish, usually finely fimbriate (upper layer), margin of lower layer often more or less covered with v- or u-shaped plates of upright hyphae from which the pillars arise. In section 0.6–1 mm. thick, composed of three distinct regions: (1) the subiculum which extends over the surface of the bark and is whitish with a tint of purple in the young, fresh condition; usually extending only about 2 mm. beyond the margin of the upper layer; 60–

90μ thick; from the basal layer numerous, short (60–70μ) upright, white, usually unbranched hyphae arise, bent at the upper end like a shepherd's crook; (2) the middle region composed of upright pillars which arise from the subiculum; pillars numerous, about 10–12 to a square mm., 20–65μ thick, most 30–40μ thick by 0.5–0.6 mm. high; (3) upper layer 125–270μ thick, arising from the pillars and composed of much entangled, branched hyphae, hymenial region 60–100μ thick, composed of upright branched threads between which there is considerable anastomosing, threads wavy and with slightly thickened walls toward the ends, about 3μ thick. Basidia formed directly from the hyphal threads. Basidia 5 x 35–40μ, coiled one to one and a half times, becoming divided by transverse walls into 5 cells, the basal cell being functionless. Basidia formed during the late fall and germinating during the spring and summer; each cell, except the basal one, germinating into a long tube which becomes swollen toward the distal end. The tubes are arranged more or less regularly side by side. From the distal end of each tube a long narrow (2 x 10–15μ) sterigma sprouts, which in turn bears a single spore on its end. Spores very irregular in size, 4.2–6.2 x 12.6–23.1μ, bent-elliptic, white in print, rarely becoming once or thrice septate.

Common on ash, often occurring on the same limbs with *S. pseudopedicellatum* Burt. *S. Patouillardii* Burt and *S. Mariani* Bres., and not rarely confluent with these species. Symbiotically associated with scale insects (*Chionaspis gleditsiae* Sanders), some of which are parasitized by irregularly coiled hyphae, others remaining free from fungal infection.

This species may be recognized with the unaided eye by the striking color (benzo brown, etc.) and the peculiar marginal characters. Through the courtesy of Dr. Pennell, I have been able to study the type material of this species which is in the Schweinitz Herbarium at the Philadelphia Academy of Natural Science. The type material, consisting of a piece about half the size of one's smallest finger, was collected by Schweinitz near Winston-Salem, N. C., over one hundred years ago. Mr. K. B. Raper has collected this species for me near Welcome, N. C., only a few miles from Winston-Salem. The microscopic structure of the type material (Plate 33, figs. 4–8) is identically the same as that of my specimens. The color of the type has faded to a drab color, but the colored picture of the type as illustrated by Schweinitz in "Synopsis fungorum Carolinae Superioris," Tab. 2, fig. 3, agrees remarkably well with the color of my material. In my study of the type material, I have been unable to find the "erect probasidia" figured by Dr. Burt (Fig. 1a); nor did I find the "spore bearing organ" attached as shown in the same figure.

This species is fairly common around Chapel Hill and I have therefore been able to keep it under observation during the past two years and to work out some of the difficult points in its life history. No persistent probasidia are formed in this species, the basidium arising directly from the hyphal threads. This structure starts as a lateral tuberous cell which elongates and becomes coiled or irregularly twisted and finally becomes divided into five cells by transverse septa. Of these five cells the basal one is apparently functionless and may indicate the remains of a once normal probasidial cell, the other four cells are the "basidium." This structure formed during the early winter remains quiescent during the winter months. In the early spring each cell of the basidium sprouts a long tube which grows up to the surface of the hymenium. From the end of this tube a slender, long sterigma grows and on the end of this a spore is borne. During the formation of the spore the cell of the basidium, the long tube, and the sterigma become empty, the protoplasm, of course, passing into the spore.

This species is fairly abundant in certain localities, but does not seem to have a wide geographic range, being known with certainty only from North and South Carolina. It is represented by eleven collections in our herbarium. Usually occurring with *S. pseudopedicellatum* and *S. Patouillardii*.

Specimens examined:

North Carolina: Near Winston-Salem, Schweinitz, coll., in Schweinitz Herbarium, Philadelphia; same loc., on *Fraxinus*, with *S. Patouillardii* and *S. pseudopedicellatum*, Oct. 28, 1928, K. B. Raper, coll., 8370; same location Dec. 27, 1933, J. R. Raper, coll., 9341; near Chapel Hill, on *Fraxinus americana*, J. N. Couch, coll. Nos. 8373, 8374, 8379, 8397, 8398, 9989; near Wilmington, on *Fraxinus americana*, Dec. 28, 1921, J. N. Couch, coll., 5876.

South Carolina: Near McBee, on *Fraxinus americana*, June 30, 1929, A. B. Couch, coll., 8319. In this collection hybridization between *S. Schweinitzii* and *S. pseudopedicellatum* was taking place.

Septobasidium Hesleri n. sp.

Plates 13 and 18

Fungus body resupinate, rather inconspicuous, the patches of growth being small, up to about 10 cm. long by 2–3 cm. wide. Pallid, purplish gray in the regions of new growth, becoming a dull sayal or snuff brown in the older parts. Surface characteristically flaky due to the incom-

plete formation of the top layer; sometimes, however, the top layer may be complete. Margin determinate or indeterminate, dotted here and there with pillars or irregular "tents" or minute flakes. In section 250–400μ thick, composed of three layers: (1) subiculum 12–20μ thick, which is covered by upright, rarely branched, encrusted, hyaline threads, about 40μ tall; (2) pillars 30–140μ thick x 100–190μ tall, usually rather few; (3) top layer 40–100μ thick. Hyphae of subhymenial region 3–4.2μ thick, dark-colored, branched; hymenial region 30–40μ thick, composed of nearly hyaline, frequently dichotomously branched, coiled hyphae, 2.8–3.2μ thick, between which there is much anastomosing, and basidia which are one to one and a half times coiled, about 4.5–5.8 x 32–38μ, divided into four cells with an additional functionless basal cell. Basidial germination as in *S. Schweinitzii*. Each cell, except the basal one, gives rise to a long tube on the end of which a narrow sterigma is formed and on the end of which, in turn, a spore is formed. Spores 5–6.3 x 13–18μ.

Symbiotically associated with scale insects (*Chionaspis gleditsiae*), some of which are parasitized by irregularly coiled haustoria, while others of the insects are free from parasitism and are in all stages of development.

The two collections of this species were in fruit but rather sparingly except on one piece of wood where the new species was growing in contact with a much more luxuriant growth of *S. pseudopedicellatum*. Along this line of contact in a zone about 0.3 cm. wide the new species was producing a vast abundance of basidia and spores. The *S. pseudopedicellatum* was not visibly affected by the contact. I have noticed other cases of greatly increased vigor in fruiting on the part of one species where two were in contact (e.g., *S. filiforme* and *S. Mariani*).

This species is closely related to *S. Schweinitzii* and *S. lilacinoalbum*, being perhaps a hybrid between the former and some unknown species.

The present species may be distinguished by its small size, thin, usually flaky structure, dull brownish color, and the inconspicuous "tents," "Esquimo huts," and pillars on the margin. The basidia and spores are as in *S. Schweinitzii* but in that species the hymenium is thicker and the sterile threads are wavy but upright while here the sterile threads are dichotomously branched and recurved, frequently coiled.

I am naming this species in honor of Dr. L. R. Hesler, who collected it.

Specimens examined:

Tennessee: Near Gatlinburg, on *Carpinus caroliniana*, June 20, 1931, U. N. C., 9906, and July 19, 1934, U. N. C., 9907, type, L. R. Hesler, coll.

Septobasidium lilacinoalbum n. sp. Hybrid between *S. Schweinitzii* and *S. Cokeri.*

Plates 16 and 34

Fungus body perennial, resupinate, occurring on the younger limbs; forming rather extensive confluent patches which often girdle the limbs and extend for a distance of 40 cm. The summer color of young fresh specimens is almost pure white but with a faint pallid-vinaceous tint, older regions ecru-drab, oldest regions dark, almost grayish black; the winter color is benzo brown or mummy or clove brown with a whitish mottled marginal region much as in typical *S. Schweinitzii.* Surface inherently smooth or sometimes minutely granulose with a lens in the young regions, often with circular elevations (the surface above each pillar being slightly elevated); in older regions becoming cracked into numerous irregular patches. Margin determinate, pure white in actively growing material. In section 360–430μ thick, composed of three distinct layers: (1) subiculum rather thin, 60–80μ thick, composed of a mat of brownish threads which extend over the bark and from which arise a weft of much thinner, hyaline, branched, curved threads which are partly encrusted with crystals, margin of subiculum extending about 1–2 mm. beyond margin of top layer; (2) middle layer composed of upright pillars which arise from the subiculum, pillars about 8–12 to a sq. mm.; very variable in thickness, 35–150μ thick by 210–250μ tall, single or in groups; hyphae of pillars 3–4.2μ thick, septate, often slightly constricted at the septa, without clamp connections; (3) top layer arising from and supported by the pillars (the threads at the top of the pillar growing outward horizontally, each pillar forming a structure like an open umbrella; threads from the tops of adjacent pillars growing together finally forming a continuous top layer), at first very thin and composed only of horizontal hyphae; hymenium arising from and finally forming the larger part of the top layer, 60–100μ thick, thin in the young regions, becoming thicker with age, composed of closely packed, more or less upright, much branched and twisted hyaline threads between which there is much anastomosing. Probasidia not formed. Basidia arising from the upright threads as small, elongated cells which directly grow into the coiled basidia. Basidium 4-celled with a fifth, basal, functionless cell; each cell of basidium giving rise to a long, thick sterigma on the end of which a spore is borne. Basidia coiled, 4.2–5 x 25–35μ, usually not more than 4.2μ thick. The basidia in old regions are often very irregular in shape. Entire top layer 92–262μ thick, the thickness depending upon age, hymenium 60–100μ thick, hyphae of top layer 2.2–3.5μ thick. Spores white, smooth, bent-elliptic, 3–4 x 10–17μ, becoming one to three times septate.

Symbiotically associated with scale insects (*Chionaspis gleditsiae* Sanders ?), some of which are parasitized by irregularly coiled haustoria while others are not parasitized.

This species is closely related to *S. Schweinitzii* Burt. The two plants are associated with the same scale insect (*Chionaspis gleditsiae* Sanders ?), but on different host plants, and the hymenial, basidial, and spore characters are much the same except for the smaller size of the basidia and spores in *S. lilacinoalbum*. The two plants may be easily distinguished. The color of *S. lilacinoalbum* is very distinct,—white with a lilac tint when fresh. The present species, moreover, is thinner than *S. Schweinitzii*. Finally the marginal characters of the two are quite different. In *S. Schweinitzii* the margin of the subiculum shows the characteristic "tent-like" elevations, while in *S. lilacinoalbum* the corresponding region is characterized by the pillars, the tops of which spread out like umbrella tops.

This species is almost certainly a hybrid formed by the crossing of *S. Schweinitzii* and *S. Cokeri*. It was first looked upon as a distinct species closely related to *S. Schweinitzii* but with the discovery of abundant material in Chapel Hill it has been possible to follow this fungus for several years during which time its hybrid nature has become quite evident. On the same tree there are a few small patches of *S. Cokeri* but no *S. Schweinitzii*. I have found several pieces (Nos. 9327 and 9384) which were colored exactly like typical *S. Schweinitzii*, benzo brown with the same mottled effect toward the margin. In these specimens which otherwise looked so much like *S. Schweinitzii* there were pillars on the margin instead of the "tent-like" structures. Usually, however, the whitish color predominates over the benzo brown. The pillars predominate over the "tent-like" marginal structures though in some places very rudimentary tent-like structures are formed. In *S. Schweinitzii* the subiculum is densely covered with upright hyphae which are curved above like a shepherd's crook; while in *S. Cokeri* the threads of the subiculum are nearly all horizontal but at the bases of the pillars there are tufts of threads covered with crystals. In the hybrid these two characters are mingled, the subiculum being covered with more or less upright encrusted threads. In *S. Schweinitzii* the sterile threads in the hymenium are vertical and slightly wavy; in *S. Cokeri* the sterile threads are recurved and neither vertical nor wavy. In the hybrid the sterile threads are vertical but much more wavy than in *S. Schweinitzii*, and are frequently coiled. In both *S. Schweinitzii* and the hybrid the sterile threads of the hymenium anastomose freely but not in *S. Cokeri*. In reproductive structures the coiled basidial characters of *S. Schweinitzii* dominate over the probasidial and basidial characters of *S. Cokeri*, i.e. in the hybrid species the probasidium is

usually lacking and the basidium is coiled as in *S. Schweinitzii*. The "probasidial cell" character is latent however, since quite frequently a type of probasidial cell about the same size and shape as in *S. Cokeri* may be formed from any one of the basidial cells. The spores are shaped like those of *S. Schweinitzii* but are considerably smaller in the material from Highlands, N. C.

Specimens examined:

North Carolina: Type near Highlands, N. C. on *Hicoria alba*, August 6, 1931. Else R. Couch, coll., 9064; Chapel Hill, near Laurel Hill on *Hicoria glabra*, October 23, 1932, Nos. 9322 and 9327; May 7, 1933, No. 9384, August 24, 1934, No. 9843, and Nov. 26, 1934, No. 9899. Very abundant on this one tree and causing great damage to the tree, having killed over half the limbs. Occurring on the same tree: *S. Mariani*, *S. Curtisii* and *S. Cokeri* and *S. apiculatum*. By marking certain specimens on this tree and following their development through the seasons it has been possible to detect that this fungus passes through remarkable color changes from season to season. During late summer and early fall the color is a beautiful white with a pale lilac tint. Specimens collected in October are pinkish buff. This color becomes darker, passing through wood brown to mummy brown by the last of November. In the spring as new growth begins, the specimens become lighter in color and pure white with the characteristic lilac tint by mid-summer.

South Carolina: Near Jacksonboro on *Hicoria* sp., March 20, 1930.

Septobasidium tenue n. sp.

Plates 9 and 37

Fungus body resupinate, very closely adherent to the bark, forming irregular isolated or confluent patches which seldom exceed six to eight cm. in length. Color quite variable, mouse gray or drab or pale gray or with a buff or brownish tint. Surface usually inherently smooth, except for minute depressions and except for very minute cracks in the older regions and irregularities in the bark. Here and there on the surface are numerous, dark, elevated areas beneath which are parasitized and non-parasitized scale insects; in old specimens these elevated dots may not be evident. Margin irregular in outline; determinate. In section about 100–225μ thick, usually about 125μ thick, in very young regions not more than 25μ thick; compact, often stratose (no. 9183) in old regions, a new hymenial stratum forming each year (no. 8456 not stratose). Context composed of much entangled, branched, septate, mostly hyaline threads, without clamp connections; threads heavily

encrusted with crystalline material; tips of threads at surface often bent like a shepherd's crook; 3.2–4.2μ thick; probasidia absent unless the sometimes thick-walled resting cells of the basidia may be considered as such. Basidia 6.3–7.5 x 29–37μ, up to 50μ long when nearly straight, but nearly always coiled and twisted, 4-celled, each cell usually giving rise to a sterigma on the end of which is formed a spore. Spores (of no. 8456) bent-elliptic, dividing into 4 or 8 cells, 2.5–4.2 x 13–22μ, most 3.2 x 16.8μ.

Associated with *Aspidiotus juglans-regiae* Comst. on bay and *Aspidiotus* sp. on oak, some of the insects being parasitized by haustoria which are in the form of miniature strings of sausages.

Very puzzling color variations occur in this species, sometimes even in the same collection. Number 8456 from South Carolina was growing on oak. In this lot of material of which there are over thirty patches of growth there is one patch nearly pure white which upon examination was found to be *S. apiculatum*. This latter species is also exceedingly thin and differs macroscopically from the species under consideration only in color and in the structure of the insect houses. The patches of growth in this collection vary in color from a drab gray to very light gray. In the lighter patches a microscopic examination shows the presence of thin-walled hyaline hyphae characteristic of *S. apiculatum*. Some of the color variation in this collection may possibly be due to the mixed growth of the mycelium of these two species.

This species may usually be recognized by the drab color, the small circular, dark elevations; and the coiled basidia. In No. 8456 there were large numbers of living algal cells embedded in the hymenial layer of the fungus.

Specimens examined:

South Carolina: Near Charleston, on *Quercus*, March 19, 1930, J. N. Couch, coll., 8456. Type.

Florida: Kissimmee, on *Quercus nigra*, March 13, 1932, J. N. Couch, coll., 9243, 9246; also near Gainesville, on *Quercus nigra*, Feb. 22, 1935, G. F. Weber and E. West, colls., Univ. Fla. Herb., 9965.

Mississippi: Near Pascagoula, on *Magnolia virginiana*, Jan. 1, 1932, J. N. Couch, coll., 9183, 9185, 9187, 9188, 9214.

Septobasidium rugulosum n. sp.

Plates 9 and 36

Fungus body resupinate, closely adherent to the bark, forming small (2–3 x 4–5 cm.) irregular, isolated or confluent patches. Color tawny

olive to sepia. Surface minutely retiform, often with dark, circular dots beneath each of which is, as a rule, a parasitized or healthy scale insect, surface rarely nearly smooth. Margin at times abruptly determinate, more often minutely fibrillose. In section 60–250μ thick, compact, composed of a basal region of thick-walled, brownish, septate threads, which are deeply constricted at the septa, threads 4–10.5μ thick. These threads when crushed separate into short segments. Upper region composed of the same type of threads except smaller; tips of threads at surface often bent like a shepherd's crook, surface threads covered with crystalline material. Probasidia absent. Basidia 4–5μ wide, about 35–42μ in length (allowing for the curvature); twisted or coiled, 4-celled, each cell giving rise to a sterigma and a spore; sterigmata often very long; basidia usually difficult to see in section. Spores 3.9–4.6 x 12.6–18.9μ, most 4 x 14μ, rarely 5 x 21μ, bent-elliptic, becoming once or thrice septate.

Associated with *Chionaspis gleditsiae* (?), some of which are parasitized by haustoria which are in the form of strings of sausages.

The adult insects in the material collected March 11–20, 1932, were giving birth to young and consequently a splendid opportunity was afforded for some observations on the fungus-insect relationship. The adult insects are beneath the fungus against the bark, each one in a sort of chamber, the roof and walls of which are formed of fungus material and the floor of which is formed by the bark. It is impossible to detect the presence of the insects beneath the fungus except by a very careful examination. If one examines the surface of the fungus with a hand lens or binocular microscope, one may see numerous, small slits, shaped like a new moon. These slits are the openings or doorways to the insects' chambers. At the time the material was first examined the adults had already given birth to large numbers of young. The young emerge through the slit openings, crawl about over the top of the fungus for a while and then settle down on top of the fungus, as a rule picking out the depressions between the ridges. The insects give off something which causes a profound change in the fungus in their immediate vicinity. After a few days, but before the insect has excreted its first scale, the fungus becomes lighter in color beneath and around the young insect. A few days later the insect has excreted its first scale and the fungus around the insect has become almost black in color. The insects are so abundant that the surface of the fungus at this time is literally peppered with these dark dots. After about two weeks the fungus beneath the insects has completely disappeared so that the insects are against the bark. As the insects sink down into the fungus new

growth begins at the surface, the threads extending over the insect so that it eventually becomes completely covered by the fungus.

Some of the living insects examined after the first moult showed the fungal haustoria within their bodies. I suspect that infection here takes place much as in *S. Burtii* and that the spores furnish the source of infection. I have been unable, however, to demonstrate this. I have examined ten young which were crawling about over the sporulating surface and although spores could be seen on the surfaces in the insects' bodies, I was unable to find any infecting cells within their bodies.

This species occurs in the same region with *S. tenue* and sometimes on the same tree and is very closely related to that form. Generally the two species may be separated by color, *S. tenue* being drab (Ridgway) while *S. rugulosum* is a rich brown (tawny olive to sepia of Ridgway). The surface of *S. rugulosum* is generally retiform while that of *S. tenue* is inherently smooth. The surface of *S. tenue* generally shows numerous, dark, elevated mounds beneath which are scale insects, whereas in *S. rugulosum* the surface of the fungus immediately over the insects is not elevated. The surface of the latter, however, is dotted with the minute dark specks which form beneath the young scale insects. In microscopic section the two species are quite similar. Both have coiled basidia but those of *S. tenue* are shorter and thicker than are those in *S. rugulosum*. The spores are quite similar in shape but differ in size, those of *S. rugulosum* being slightly thicker and shorter. The threads in the context of the two plants are quite dissimilar. Those of *S. rugulosum* are composed of short segments, the threads showing rather deep constrictions at the joints. When a mass of these threads are crushed, they separate into short joints. The threads also are generally coiled and twisted. In *S. tenue* the threads are composed of long, more or less straight, segments, are not constricted at the joints and do not separate into short segments when crushed.

Specimens examined:

South Carolina: Jacksonboro, on *Liquidambar styraciflua*, March 20, 1930, J. N. Couch, coll., 8472, type; near Myrtle Beach, on *Liquidambar styraciflua*, July 4, 1928, J. N. Couch, coll., 8314.

Florida: Jacksonville road near Ga. line, on *Liquidambar styraciflua* associated with *Chionaspis gleditsiae*, March 11, 1932, 9229; near Kissimmee, on *Magnolia virginiana*, March 13, 1932, J. N. Couch, coll., 9251; also 9244.

Louisiana: Near Baton Rouge, on *Quercus* sp., Dec. 31, 1931, J. N. Couch, coll., 9154.

Septobasidium canescens Burt. Ann. Mo. Bot. Gard. **3**: 342, fig. 13. 1916.

Plates 7 and 38

Fungus body resupinate, covering several square centimeters on the bark of *Quercus*. Pale olive buff, the olive color due to the presence of algae mixed among the hyphae. Surface irregular, due to numerous bumps and cracks, cottony in places. Margin thin but determinate. In section 450–1,000μ thick, not differentiated into layers. Hyphae in the subiculum rather closely packed and extending more or less horizontally from the subiculum; the hyphae arising obliquely to form the loosely woven branched threads of the context; hyphae 3–5μ thick, hyaline, septate, without clamps. In the older parts the hyphae are thick-walled, much septate, and constricted at the joints. Hymenial region irregularly arranged, not forming a distinct layer, composed of probasidia and basidia in various stages of development. Probasidia spherical, 10.5–19μ, usually 15–16μ thick, basidia arising from the probasidia which are left as empty cells. Basidia 9.2–10.5 x 50–63μ, thickest at the distal end, divided at maturity into 2, 3, or 4 cells by transverse walls. Usually three-celled, the distal cell being much larger than the proximal two cells. The basidia are typically very irregular in the material examined by me and very few have any sterigmata. Usually the 2 or 3-celled basidia have thickened walls—an adaptation perhaps to development in dry climate. Spores 6.3–9.6 x 18–21.8μ, hyaline, bent-elliptic.

Associated with scale insects, some of which are parasitized by irregular coils while others are free from infection.

This fungus may be recognized by the whitish, irregular, cottony surface (under lens), the lack of pillars, the spherical, hyaline probasidia, and the irregular basidia. The mycelium and the irregular basidia suggest a relationship to *Septobasidium apiculatum*.

Specimens examined:

California: Part of type in Farlow Herbarium, 1915; Pasadena, on *Quercus*, A. G. Smith, June 15, 1914; same location, March 13, 1915; Tustin, March 1921, on *Quercus agrifolia*, H. S. Fawcett, coll.; Pasadena, Dec. 22, 1933, on *Quercus agrifolia*.

Septobasidium apiculatum n. sp.

Plates 12 and 39

Fungus body resupinate, forming rather inconspicuous, small, more or less circular or irregular patches on living bark, up to 5 x 10 cm. in

area; typically sordid white in color, when fresh, sometimes with a fleshy or buffy tint. Surface inherently finely granulose but with numerous bumps and irregularities partly due to the roughness of the bark, also with numerous mounds on the top of each of which is a single spine about 1.5 mm. high, mounds up to 1.5 mm. wide. In section 250–550μ thick in well developed specimens, usually about 275μ thick, compact, often stratose due to the formation of successive hymenial layers. Threads of context 4–5μ thick, septate, constricted at joints, without clamp connections. Probasidia thin-walled, hyaline, ovoid, elongating and enlarging to form the basidia. Basidia elongated, club-shaped, 6.8–8.4 x 23–32μ, 3-celled, each cell giving rise to a long sterigma on the end of which a spore is formed. Spores 4.6–6.3 x 13–25μ, most about 5.4 x 17.8μ, bent-elliptic. Haustoria composed of elliptic cells held together by very fine threads.

Symbiotically associated with several species of scale insects, the species depending upon the host plant. In such an association some of the insects are parasitized by spindle-shaped hyphae while others are left free to reproduce. On *Cornus amomum*, associated with *Aspidiotus ancylus* which are parasitized through the body wall by the mouth, also sometimes associated with *A. juglans-regiae* and *A. forbesi*. Large numbers of the two species *Chrysomphalus tenebricosus* Comst. and *Parlatoria proteus* are present beneath the fungus on *Cornus amomum*, but none are parasitized. On sweet bay (*Magnolia virginiana*), associated with *Aspidiotus diffinis* Newst. and on pin oak (*Quercus palustris*), associated with *A. osborni* New. & Ckll.

Easily recognized by the thin white growth with the upright fascicles of hyphae.

This species is abundant in the Coker Arboretum and since the material was easily obtained some observations have been made to determine some of the details in the fungus-insect relationship. The observations were made mostly on material on *Cornus amomum*.

It has been determined that the fungus is perennial. In fact several patches of fungus growth have been marked and kept under observation since 1928. At all times during the year it is possible to find living, healthy scale insects beneath the fungus. The association between the insect colony and the fungus is therefore of a permanent nature depending only upon the life of the tree or shrub.

During winter the probasidial cells of the fungus are formed. Except for this activity the fungus is dormant. During this period there are vast numbers of healthy overwintering females and a few males beneath the fungus. There are also a considerable number of parasitized insects beneath the fungus but such insects are much less abundant during the dormant than during the growing season.

With the coming of the warm rains of spring, the fungus starts growing and fruiting and the overwintering female insects, which have been impregnated some weeks earlier, begin giving birth to young. Whereas the spores are formed only during damp warm weather, the young insects crawl out at all times though they appear to be more abundant on cloudy, warm days.

The fungus appears to have a chemotactic attraction for the insects, for though they are free to settle down where they will by far the greater number settle down on the surface of the fungus rather than on the bark. This is all the more remarkable in view of the fact that the young when not associated with the fungus normally seek some crack or shelter under the bark. I have been unable as yet (May 25, 1932) to determine if the young are infected by spores or if they are congenitally infected.

A few days after the young settle down their bodies become completely covered by the white pellicle (white in *A. ancylus*) excreted by the insect. In a few days more the fungus begins to grow up around the insect on all sides, forming a sort of circular pen around the latter. The insect continues to increase in size. After a week to ten days the fungus has almost completely disappeared beneath the insect, digested by enzymes excreted by the insect or worn away by the movements of the latter, and thus the insect comes to lie directly on the bark. Meanwhile the fungus continues to grow upward over the insect's scale, forming finally a mound-like covering on the top of which is one or more long vertical peaks. The ceiling of the fungal house is formed by the insect's scales which are so thoroughly overgrown by the fungus that they adhere firmly to it, and the floor of the house is the bark. The insects, therefore, are nowhere in contact with the fungus.

There are several species of small parasitic hymenopterous wasps which prey on this scale and the insects in the fungal houses are partly protected from such enemies.

Other insects which settle down on the fungus become parasitized by it. Why some are parasitized while others are free from infection, I cannot say as yet. The parasitized insects are covered by a comparatively very thick mat of fungal hyphae, which, though completely surrounding the insect, is not closely pressed to the latter except around the mouth area. Such insects contain numerous tufts of haustoria which are in the form of spindle-shaped cells held together by fine threads. The hyphae which connect the haustoria with the fungal pad pass through the insects' derm by the mouth. The parasitized

insects live longer than the healthy ones though the former are incapable of reproducing.

Specimens examined:

Virginia: Mecklenburg Co., on *Cornus florida*, with *S. filiforme*, 8179.

North Carolina: Chapel Hill, on *Cornus florida* and *C. amomum*, common at all times of the year, twenty-seven collections; on *Hicoria* sp. 9323; on *Quercus phellos*, March 11, 1929, 8390, type; on *Quercus palustris*, 8492; on *Liquidambar styraciflua*, 9334; on *Pyrus japonica*, 9078; on *Carpinus caroliniana*, 9391; on *Cercis canadensis*, 9386, 9387; near Raleigh, on *Cornus florida*, May 15, 1929, B. B. Fulton, coll., 8410; Pasquotank County, on *Cornus florida*, Willard Hewitt, coll., 9366.

South Carolina: Near Charleston, on *Quercus*, March 19, 1930, J. N. Couch, coll., 8459; St. Helena's Island, on *Liquidambar styraciflua*, March 21, 1930, 8486; on *Magnolia virgiana*, March 21, 1930, 8484.

Florida: Near Brooksville (host ?), March 17, 1932, J. N. Couch, coll., 9280; near Tallahassee, on *Liquidambar styraciflua*, March 17, 1932, J. N. Couch, coll., 9281.

Louisiana: Near Baton Rouge, on *Liquidambar styraciflua*, Nov. 21, 1932, C. A. Brown, coll., 567, and U. N. C., 9952.

Arkansas: Near Little Rock, on *Quercus phellos*, April 12, 1933, Dow V. Baxter, U. N. C., 9377.

Septobasidium sinuosum n. sp.

Plates 8 and 29

Fungus body resupinate, often covering an area 20 cm. long by two or more centimeters wide. Surface repeatedly divided by irregular, sinuous, anastomosing ridges, especially toward the margin and often throughout; sometimes nearly smooth in the center with a few minute holes; old areas often becoming cracked; pallid mouse gray or pallid purplish gray to Quaker drab or purplish gray, sometimes with dark dots here and there. Margin thin, whitish, myceloid. In section 400–600μ thick, composed of three rather indistinct regions or layers: (1) the subiculum, a thin inconspicuous layer (about 20μ thick) which grows horizontally over the surface of the bark, threads of subiculum about 2.2μ thick, hyaline in regions or deep mouse gray to sordid purplish brown; (2) middle layer concolorous with the subiculum, usually 300–400μ thick, composed of rather loosely packed, nearly dichotomously branched, entangled hyphae; hyphae 2–2.4μ thick, hyaline or brownish under the microscope, often with dark colored hyphae intermingled with hyaline threads, without clamp connections, peculiar in

that under an oil immersion lens the walls are distinctly warted, punctate or spiny; (3) hymenial layer, which is usually hyaline, 50–120μ thick, composed of very densely packed, twisted and much entangled hyphae, the ends of which are slightly coiled, probasidia and basidia in various stages of development. Probasidia spherical or slightly subspherical, 5.8–7.2μ thick, germinating to form a cylindrical basidium, the probasidium becoming entirely empty during the process. Basidium 3.8–4.4 x 20–32μ, becoming once septate by a transverse wall, each cell of the basidium sprouting a long sterigma which grows to the outer surface of the hymenium and there bears a spore. Sterigmata 18–25μ long. Spores smooth, sausage-shaped, 4–5 x 11.5–16.8μ, most 4.2 x 12.6μ.

This species shows a great variation in color, sometimes being very light colored, nearly white, and at other times a very deep, dull purplish brown. It can readily be recognized by the peculiar surface which is divided up by anastomosing, sinuous ridges as in some crustaceous lichens. This species has been confused with *S. Langloisii* (for a comparison of the two see under *S. Langloisii*).

Associated with scale insects, some of which are parasitized by peculiar sausage-shaped hyphae while others are free from parasitism.

Very common (represented by 41 collections) from southeastern North Carolina southward along the coastal region and westward to New Orleans and perhaps farther.

Specimens examined:

North Carolina: Near Wilmington, on *Carpinus caroliniana*, Dec. 30, 1921, J. N. Couch and F. A. Grant, colls., 4955; near Wilmington, on *Liquidambar styraciflua*, Dec. 28, 1922, Couch and Grant, colls., 5934; near Magnolia, on *Cornus florida*, in fruit, Jan. 1, 1928, A. C. Mathews, coll., 8301, type.

South Carolina: Lynch's river bottom, near McBee, on *Liquidambar styraciflua*, June 30, 1928, A. B. Couch, coll., 8316; also on *Ilex opaca*, J. N. Couch, coll., 8321; near Georgetown on *Myrica carolinensis*, July 2, 1928, J. N. Couch, coll., 8322; near Georgetown, on *Quercus phellos*, July 3, 1928, 8323 A; Myrtle Beach on *Quercus nigra*, August 29, 1931, associated with *Aspidiotus osborni*, J. N. Couch, coll., 9099.

Florida: Very abundant as far south as Sebring. Near Jacksonville, Kissimmee, Brooksville, and Tallahassee, J. N. Couch, coll.; on *Quercus laurifolia*, Gainesville, G. F. Weber, coll., 9410, 9964; also Gainesville, H. E. Stevens, coll., Mo. Bot. Gard. Herb., 44211, under *S. Langloisii* Pat.

Mississippi: Pascagoula, common on several species of *Quercus, Cornus florida, Liquidambar,* also a variety on *Magnolia virginiana,* with a nearly smooth not sinuous (or only slightly sinuous in places) surface, somewhat cracked in older parts. Color dark vinaceous gray. Probasidia, basidia, and spores smaller than in type. Spores 3–4 x 10–13.8μ. Jan. 1, 1932, J. N. Couch, coll.

Louisiana: New Orleans, on *Liquidambar styraciflua,* Dec. 31, 1932, Donald Rogers, 9935; Baton Rouge, on *Liquidambar styraciflua,* Jan. 8, 1932, Clair A. Brown, 9705; also 9706 from same locality on *Quercus nigra;* and 9178 on vine (*Aristolochia*?) Dec. 31, 1931, J. N. Couch.

Septobasidium Langloisii Pat. Bull. Soc. Myc. Fr. **16:** 54. 1900.

Plates 8 and 41

Fungus body resupinate, covering very extensive areas, sometimes up to several square decimeters in extent, on the main stem and branches of a variety of trees. Color pale violet plumbeous (Ridgway), or about grayish blue. Surface usually very irregular, retiform or with conspicuous cracks in the older areas, rarely nearly smooth or with minute holes. Margin usually determinate and with conspicuous rhizomorphs. In section 400–500μ thick, compact except for tunnels which are abundant in the younger parts. Context 330–420μ thick, composed of rather loosely packed, much branched, entangled, brown, septate threads, without clamps, 2.8–3.8μ thick, often swollen. Hymenium 60–80μ thick, composed of brownish threads which branch out to form very thin (about 1.5μ thick) hyaline upright threads and probasidia and basidia in various stages of development. Probasidium 8.4–12.6μ thick, spherical or slightly subspherical, germinating to form a somewhat ovoid basidium, and remaining as an empty cell at the base of the basidium. Basidia 2-celled, 6.7–12 x 21–29μ, most about 8 x 23μ, usually thickest in the middle part, sometimes thickest in the distal half; sterigmata 10–25μ long, borne on both cells of the basidium. Spores elliptic, flattened on one side, sometimes pointed at each end, 6–8.4 x 13.8–21μ.

Symbiotically associated with scale insects (*Aspidiotus* sp.) some of which are parasitized by hyphae composed of spindle-shaped segments connected by very fine threads, some of these threads being more or less straight while others are irregularly coiled. Other insects are free from parasitism and are in all stages of development.

This fungus may be distinguished by its color, the absence of pillars, and by the peculiar marginal and surface characters. Some of the specimens are remarkably beautiful in color and symmetry. The fungus has doubtless been passed over as a crustose lichen.

Septobasidium sinuosum n. sp. has been confused with this species. Both species occur abundantly in the Gulf States but while *S. Langloisii* occurs only in the Gulf States, *S. sinuosum* extends as far north as southeastern North Carolina. Though the two species may easily be confused, they are quite distinct. *S. sinuosum* is usually lighter in color being a pallid mouse gray or when darker, quaker drab to purplish gray, while *S. Langloisii* is usually pale violet plumbeous. The two may also be distinguished by the surface characters, *S. sinuosum* having a distinctly bumpy and sinuously ridged surface, the ridges being rounded; *S. Langloisii* also has a surface with ridges but the ridges are not so distinct, and their surfaces are more flattened and their margins are not rounded but appear to have been eaten away. The margin of *S. sinuosum* is usually without conspicuous rhizomorphs, while in *S. Langloisii* the dark colored rhizomorphs are quite distinct. Microscopically the two are distinct. In *S. sinuosum* the probasidia are 5.8–7.2μ thick, the basidia 3.8–4.4 x 20–32μ, the spores 4–5 x 11.5–16.8μ; in *S. Langloisii* the probasidia are 8.4–12.6μ thick, the basidia 6.7–12 x 21–29μ, spores 6–8.4 x 13.8–21μ. Thus in *S. Langloisii* the probasidia, basidia, and spores are distinctly larger than in *S. sinuosum*.

This species is common on the Gulf Coast and in Florida, apparently being limited in its American distribution to this region. Usually found on *Magnolia virginiana*, but also occurring on *Fraxinus*, *Carpinus*, *Nyssa*, and a few other trees. Often found on the main trunk near the base as well as on the limbs.

Specimens examined:

Louisiana: Type, near St. Martinsville, on *Crataegus arborescens*, May 11, 1899, Langlois, 2995, in Patouillard Herb., Harvard, fertile; near Baton Rouge, on *Crataegus*, Dec. 31, 1931, J. N. Couch, 9172.

Mississippi: Pascagoula, very abundant on *Magnolia virginiana*, Jan. 1, 1932, J. N. Couch, 9186, 9194, 9195, 9196, 9198; also near Ocean Springs, June 1896, in N. Y. Bot. Gard. Herb.

Florida: Daytona, Jan. 1898, Thaxter, Farlow Herbarium; Brooksville, on *Carpinus*, very abundant, almost every tree infected, March 17, 1932, J. N. Couch, 9281; Sebring, on *Fraxinus*, March 14, 1932, 9268, also on unidentified trees, 9271, 9272, 9273; near Kissimmee, on *Fraxinus*, March 13, 1932, J. N. Couch, 9247, also on unidentified trees 9237, 9249; near Tallahassee, on (?), March 17, 1932, J. N. Couch, 9286; near Orlando, on *Magnolia virginiana*, very common, March 12, 1932, 9956; Ichtucknee Springs, near Fort White,

on *Carpinus*, Feb. 1, 1935, Dow V. Baxter, coll., 9967, surface nearly smooth; same locality Feb. 3, L. E. Arnold and E. West, colls., Univ. Fla. Herb., 9939.

Cuba: La Prenda, Dec. 1921, U. S. D. A. Herb., also U. N. C. Herb. Form with pillars and nodulose surface. Probasidia spherical, 10–12.6μ, basidia 2-celled, about 8 x 25μ, haustoria typical.

Septobasidium sabalis n. sp.

Plates 14 and 40

Fungus body resupinate, spreading about over the surface of the petiole and blade of palmetto leaves, covering an area up to 100 sq. cm. or perhaps more; vinaceous buff to wood brown (Ridgway). Surface smooth, almost shiny. Margin usually determinate but irregular in outline. In section up to 1 mm. thick, composed of (1) a very thin subiculum about 50μ thick from which arise short pillars, 80–125μ tall, which support (2) another, thicker horizontal layer, 80–125μ thick. This second layer is often incompletely developed. Between these two layers the scale insects live. From the bottom layer and sometimes from the second arise the pillars. The pillars pass up through the second layer branching out at their tops to form the third or top layer. Pillars quite inconspicuous, about 15–20 to a square mm., 20–70 x 275–375μ, branching out at the top to form a thick region of loosely interwoven hyphae, about 4.2μ thick, septate without clamps, this region about 500–600μ thick. Hymenium borne on surface of top layer, about 120μ thick, composed of much branched, entangled hyphae which are more densely packed than in the underlying context; and probasidia and basidia in various stages of development. Probasidium subspherical or pyriform, 9.6–12.6 x 15–22μ, sprouting and emptying its contents to form a cylindrical basidium. Basidium 8.4–9.6 x 42–50μ, usually thickest in the distal part, sometimes thickest in the middle, once septate by a transverse wall when mature. Each cell of basidium giving rise to a long sterigma up to 30μ long on the end of which is borne a spore. Spores 5.4–8.4 x 19–27μ, most 6.7 x 25μ, recurved at the distal end, broadest at the mucro end, becoming divided into a number of cells by cross and longitudinal partitions.

Symbiotically associated with *Aspidiotus* (?) *sabalis* Comst., some of which are parasitized by coiled hyphae while vast numbers, in all stages of development, are free from parasitism. The species of scale insect agrees well with Comstock's description of *Aspidiotus* (?) *sabalis*. The scale is snow white and nearly circular. The leaf blades and petioles are remarkably free from the insects except beneath the fungus. In this species the subiculum penetrates the stomatal openings, developing

tufts of hyphae within the openings. These hyphae apparently do not enter the cells.

It may be distinguished from other species by its habit on the Sabal palmetto, by having a subiculum and then a second layer a short distance above the subiculum in addition to the usual horizontal top layer. In the possession of three horizontal layers this species resembles *S. Mariani* Bres. The two bottom layers may grow together in old specimens so that only one layer, the subiculum is evident. The narrow pillars and the very thick top layer composed of very loosely woven hyphae are other distinguishing characters. Microscopically, the large two-celled basidium and the irregularly septate spore, recurved at the distal end, may help in identification.

Specimens examined:

Louisiana: Near Baton Rouge, on leaves and petioles of *Sabal Deeringiana*, Dec. 26, 1931, C. A. Brown, coll., 317, also U. N. C., 9151, type; near Denham Springs, on leaves and petioles, *Sabal Deeringiana*, Jan. 10, 1932, C. A. Brown, coll., 325; also U. N. C., 9210; near New Orleans, on leaves of *Sabal Deeringiana*, Oct. 26, 1933, M. L. Bomhard and W. T. Swingle, colls., U. S. D. A. Herb. and U. N. C. Herb., 9959.

Septobasidium Patouillardii Burt. Ann. Mo. Bot. Gard. **3**: 332. 1916.

Plates 13, 15, 42

Fungus body resupinate, forming irregular patches which are usually rather small but which may be up to 20 cm. in length; snuff brown or sepia to mummy brown or clove brown to blackish brown with a velvety appearance and a purplish tint, the latter combination of colors being the most characteristic. Surface smooth in the younger regions, cracked in the older parts. Margin irregular in outline, sharply determinate, the lower layer usually not extending beyond the top layer. In section 300–460μ thick, composed of three regions: (1) the subiculum which extends over the bark and is very thin (about 20μ), composed of interwoven, septate hyphae, about tan colored and contrasting strikingly with the darker top layer; hyphae about 3μ thick; (2) a region of very slender, upright pillars which are 20–54 x 140μ, hyphae of pillars about 4μ thick, branching out toward the top to form (3) the top layer which bears the hymenium. Top layer 100–210μ thick, sometimes stratose, the lower part of top layer composed of loosely interwoven, much branched threads which are about 3.5–4μ thick; hymenium 28–38μ thick, sharply distinct from the rest of the top layer by its much darker color, the darker color being due to the paraphyses; paraphyses vertical,

thick-walled, about 3.2μ thick. Probasidia absent unless the small, thin-walled, elongated, transitory cell (see figure) which elongates and enlarges to form the basidia may be considered as such. Basidia elongated, 2-celled, 5.2–5.6 x 18–23μ, each cell giving rise to a sterigma and a spore, sterigmata 20–25μ long. Spores 4.2–5.8 x 10.9–16.6, rarely up to 21μ long, bent-elliptic, hyaline, becoming thrice septate.

Symbiotically associated with *Chionaspis gleditsiae* some of which are parasitized by very irregularly coiled hyphae, others of which are free from fungal infection. Perennial, the spores forming during spring and early summer.

This species often occurs along with *S. Schweinitzii*, *S. pseudopedicellatum*, *S. Curtisii*, *S. Mariani*, and *S. castaneum*, but may easily be distinguished from any of those on the basis of color and structure. The blackish velvety top surface, contrasting with the lighter (usually tan) colored subiculum, the thinness of the plant body, the minute slender pillars, and the distinct, abruptly determinate margin are macroscopic characters by which the present fungus may be distinguished. The vertical paraphyses in the hymenium and the two-celled basidium without a persistent probasidial cell are the most striking microscopic characters. It is very easy, indeed, to recognize this plant from Burt's description. Burt says, "This species may be recognized by its thin fructification resembling a piece of black velvet, slightly raised from the substratum on such short and slender pillars as to be barely visible without the aid of a lens." However, Burt describes the plant as having probasidia. He states that the material with probasidia was "near a specimen of another species." I have examined a large amount of sectioned material collected in February and March, both just before and during the formation of basidia, and have been unable to find any probasidia as described and figured by Burt. It is my opinion that the probasidia belonged to another species.

I have collected this species in North Carolina, Florida, Mississippi, and Louisiana. Type in Burt Herb.

Specimens examined:

North Carolina: Near Pee Dee, on live *Fraxinus*, March 24, 1926; near Wilmington, on *Fraxinus*, with *S. Schweinitzii*, Dec. 28, 1921, J. N. Couch, coll., 5876; near Winston-Salem, on *Fraxinus*, with *S. Schweinitzii*, Oct. 28, 1928, Kenneth B. Raper, coll., 8370, also on *Fraxinus*, with *S. Schweinitzii*, Dec. 27, 1933, John R. Raper, coll.; Chapel Hill, rather common in swampy regions, on *Fraxinus*, Feb.

5, 1929, 8386; also March 8, 1929, 8393, and March 14, 1929, 8396, the last two collections fertile; also same locality, Oct. 28, 1928, 8373 and 8374.

South Carolina: Lynch's river bottom near McBee, on *Fraxinus*, June 30, 1928, A. B. Couch and J. N. Couch, colls., 8319.

Florida: Daytona, R. Thaxter, No. 75b, in Farlow Herb. and Mo. Bot. Gard. Herb., 43895; near Kissimmee, on *Fraxinus*, March 13, 1932, J. N. Couch, coll., 9298, fertile, sepia to clove brown, the fertile specimens slate colored; near Lisbon, on *Fraxinus* (?), Jan. 24, 1891, L. M. Underwood, coll., 2908. Determined by J. R. Weir as *S. fumigatum* Burt? in U. S. D. A. Herb., also fragment in U. N. C. Herb.

Louisiana: St. Martinsville, A. B. Langlois, 3005, type, in Burt Herb.; near Baton Rouge, very abundant on *Ilex decidua*, 9168, and 9170, on *Fraxinus* Dec. 31, 1931, J. N. Couch, coll., 9169; on *Gleditsia triacanthos*, with *S. pseudopedicellatum*, Dec. 31, 1931, J. N. Couch, coll., 9161.

Septobasidium grandisporum n. sp.

Plates 5 and 43

Fungus body resupinate, forming extensive patches on the living bark of dogwood, often girdling the trunk for a height of several decimeters. Hymenium usually pale smoke gray (Ridgway) when well developed, vegetative parts brownish black. Surface spongy except where the hymenium is well formed, then with numerous cracks and holes; even the smoothest places are distinctly bumpy under a lens. Margin usually determinate, often with distinct rhizomorphs. In section up to 2.5 mm. thick, composed, in mature specimens, of the hymenial region and the context but with no distinct subiculum. Context composed of rhizomorphs which extend about over the bark, from which a vast tangle of fascicles of hyphae arise, giving the context a spongy texture. Hyphae of context much branched, septate, without clamp-connections, 3 x 4.2μ in diameter. Hymenial region 150–250μ thick, composed of more or less upright, much branched, hyaline and brownish hyphae, 3–3.5μ thick, and probasidia and basidia in various stages of development. Probasidium usually slightly subspherical, 12–17μ thick, sprouting and emptying its entire contents to form the basidium. Basidium long-cylindrical, often curved, thickest at the distal end, 8.4–9.6 x 46–56μ, giving rise to an apical sterigma, 8–22μ long, on the end of which is borne one spore. Spores elliptic, 12.6–17 x 29–32μ, most about 16.8 x 29.5μ, becoming irregularly septate into a number of cells, hyaline at first but becoming brownish if kept on slide for several days.

Symbiotically associated with *Chrysomphalus obscurus* (Comst.), some of which are parasitized by hyphae which are in spindle-shaped segments (as in *S. fumigatum*) and others of which are free from parasitism. Both parasitized and healthy insects, the latter in all stages of development, are very abundant beneath the fungus.

This species is apparently very rare, having been collected but once, and then on two trees of *Cornus florida* in woods by highway about 30 miles north of Charleston, S. C., March 19, 1930, Else R. Couch, collector. The fungus was very abundant on the infested trees and both trees were very unhealthy, there being a number of dead limbs and other living ones growing in the form of witches' brooms. As in other species the fungus does not penetrate into the wood, the injury being done by the insects.

This species may be confused with *S. fumigatum* Burt, which occurs in the same locality and sometimes on dogwood. They look considerably alike to the naked eye, both have a grayish hymenium and spongy context. In *S. fumigatum* the context is brownish, the hymenium mouse gray and the plant has a smooth, velvety feel. In the present species the context is brownish black, the hymenium smoke gray, and the surface of the plant has a distinctly rough or coarse feel. The haustoria in the two plants are alike but the probasidia, basidia, and spores are distinct.

Specimen examined:

South Carolina: About 30 miles north of Charleston, on two trees of *Cornus florida*, March 19, 1930, Else R. Couch, coll., U. N. C. Herb., 8465, type.

Septobasidium pilosum Boedijn and Steinmann. Arch. Theecult. **4**: 48. 1930.

Plates 7 and 18

This remarkable species described from Java on tea has recently been found in Florida on *Mangifera indica* and in Louisiana on *Magnolia virginiana*.

Fungus body resupinate, forming cushion-like patches of growth 1–10 mm. wide by 1.5 mm. high. Color deep brown. Surface minutely setose; margin determinate. In section not divided into layers, about 0.8–1.5 mm. thick. In the basal region rather few, thick hyphae extend over the surface of the bark, penetrating into the cracks; from these

hyphae arise rather closely packed, entangled, upright and mostly straight, frequently septate, dark colored, unbranched threads, 6–10μ, usually about 8.4μ thick. In the type these upright threads may be single or several may arise together, forming a small loose fascicle 10–50μ thick; threads of type 5–8μ thick, tips of threads hyaline. From the sides of the hyphae, particularly in their basal parts, just below the septum, are borne clusters of conidia, the individual cells of the cluster are hyaline at first but later become dark and thick-walled, 8–11.7μ thick. The individual cells of the cluster do not separate but the entire mass falls off. On these "multicellular conidia" or conidial bodies a distinct stalk cell is evident; conidial bodies irregular in shape but usually rounded, 25–65μ thick. Probasidia not formed in material from Florida but in the type material the probasidia are formed on the ends of short septate branches which apparently start off as conidia. Probasidia spherical, sometimes minutely rough, usually 16.8μ thick but varying from 12–17μ thick. Germination not seen.

Associated with scale insects, some of which are parasitized by hyphae the main branches of which are composed of spindle-shaped segments held together by fine threads. From these branches numerous coiled masses of spindle-shaped cells connected by fine threads arise. The sausage-shaped haustoria are connected with the external fungus through the derm pores as in *S. Burtii*.

The material from Florida differs from the type in having thicker hyphae and in the fact that the upright hyphae arise singly and not in fascicles as frequently happens in the type. Also the Florida material lacks the probasidia. Except for these slight differences the two fungi are strikingly alike. The basidia have not yet been found but the presence of the very highly specialized and distinctive haustoria typical of certain other species of *Septobasidium* is sufficient evidence that the two collections belong to that genus. The collection from Louisiana on *Magnolia virginiana* is producing probasidia, though I was unable to find any basidia. In color and other characters it resembles the type. The conidial form of *Septobasidium* studied by Petch (Trans. Brit. Myc. Soc. **11**: 62–65, 1926) on tea from Formosa also doubtless belongs here, as suggested by Boedijn and Steinmann (1930).

Specimens examined:

Java: Type, on tea, Steinmann, coll.; on *Artabotrys*, Dakkus, coll.

Formosa: On tea, Yaizw, Province Sugura, K. Hara, coll., studied by Petch.

Louisiana: Near Baton Rouge, on *Magnolia virginiana*, Dec., 1931, J. N. Couch, coll.

Florida: Delbray, on *Mangifera indica*, May 29, 1934, L. S. Light Jr., coll.; also on *Mangifera indica*, near Oneco, Feb. 12, 1935, Comm. by E. West. With *Leucaspis indica*.

Septobasidium Peckii n. sp.

Plate 17

Fungus body resupinate, forming small inconspicuous patches of growth (3 x 6 cm. in the one specimen seen). Tawny to russet or hazel. Surface composed of usually flat, sinuose plates; i.e. the top surface is incompletely formed. Margin determinate but subiculum is indistinct, with a few very inconspicuous (visible only with lens) pillars. In section 500–1000μ thick; composed of a very thin subiculum which forms a continuous layer next the bark, from which arise very short pillars the hyphae of which branch out above to form the top layer which may be 500μ thick. Hyphae of top layer upright, frequently grouped into columns between which are small spaces, so that the top layer in section has a somewhat spongy appearance. Hymenium immature, composed of upright, closely compacted threads which give rise laterally to the probasidia, the latter being immature. Hyphae of subiculum, hyaline, in younger parts thin-walled, about 3μ thick, hyphae of pillars, and subhymenial region pale brownish, 3.8–4μ thick, hyphae of hymenium 3.8–4μ thick.

Associated with scale insects (*Chionaspis* sp.), some of which are parasitized by irregular coils while others are free from parasitism.

The species is easily distinguished from all others by its striking tawny to russet color, surface appearance, and the peculiar hymenium with the upright threads. The fungus, collected in October, does not show mature fruiting structures but the structure of the immature hymenium and the old hymenium of the preceding spring suggests a relationship to *S. albidum*, which occurs in Equador and *S. flavo-brunneum*, which occurs in Java.

Specimens examined:

New York: Near Indian Lake, on living branches of *Alnus incana*, October, Chas. H. Peck. Type in Patouillard Herb., Harvard Univ., labelled *T. pedicellata* Schw.

Septobasidium sp. hybrid between *S. castaneum* and *S. Patouillardii* (?).

I have six collections of a species from Louisiana and Alabama which I at first put under *S. Patouillardii* but a more detailed study of these forms has indicated their distinctness from that species.

Fungus body resupinate, forming thin, closely adherent, irregular, confluent, patches up to 10 cm. long. Bister (Ridgway) or slightly lighter. Surface smooth except for the wrinkles in the bark and distinct cracks in older parts. Margin abruptly determinate, the margins of the top and bottom layers usually ending at the same place, irregular in outline. In section 160–520μ thick, usually 210–315μ thick, composed of three regions: (1) the subiculum which is very thin, 20–70μ thick, usually about 40μ thick, composed of densely packed threads, 3–4.2μ thick, which extend in a more or less horizontal direction, subiculum concolorous with top layer or slightly lighter; (2) the middle region composed of scattered pillars or very thick columns of hyphae, 100–1000μ thick and only 50–80μ tall, threads of pillars 3.6–4.2μ thick, concolorous with threads of subiculum; (3) the top layer supported by the pillars or columns, 55–150μ, usually about 65μ thick, composed of closely packed and entangled hyphae the ends of which are not arranged vertically but are recurved, hyphae 3.8–4.2μ thick, concolorous with the pillars and subiculum. Probasidia and basidia not observed.

Associated with scale insects some of which are parasitized by irregular coils of hyphae.

This species is related to *S. castaneum* Burt, *S. Patouillardii* Burt, and *S. Leprieurii* (Mont.) Pat. From *S. castaneum* it differs in being much thinner, in having a simple margin, in having two instead of three horizontal layers, in having a middle region composed of distinct pillars or columns of hyphae and empty spaces instead of branched pillars and flocculent hyphae. The color of the two is also different, *S. castaneum* showing more of a purplish tint in the brown than the present species. From *S. Patouillardii* Burt it differs in color, being bister without a velvety sheen instead of blackish brown with a faint purplish tint and with a velvety sheen, in having very thick, stubby pillars instead of thin slender ones, in having a subiculum concolorous with the top layer instead of distinctly lighter and in having the ends of the threads in the top layer recurved instead of vertical. From *S. Leprieurii* it differs in having pillars throughout, in being much thinner, and having a tough, crusty texture when torn with a needle instead of a soft, flocculent one. The color of the two species is somewhat similar, though *S. Leprieurii* has a shiny instead of dull surface. *Septobasidium Leprieurii* is also somewhat lighter colored.

This species has so far been found only on *Liquidambar styraciflua*, and although the material is abundant it is all sterile.

Specimens examined:

Louisiana: Near Baton Rouge, Dec. 31, 1931, with *S. Mariani*, *S. pseudopedicellatum*, and *S. castaneum*, J. N. Couch, coll., 9181, 9193; also near Baton Rouge, Dec. 26, 1931, C. A. Brown, coll., 326, U. N. C., 9946; near Covington, Jan. 10, 1932, with *S. castaneum* Burt, C. A. Brown, coll., 321, U. N. C., 9949.

Alabama: Near Nokomis, April 19, 1932, C. L. Shear, coll., in U. S. D. A. Herb. and U. N. C., 9948.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

EXPLANATION OF PLATES

The drawings were made by the author and inked in by Miss Alma Holland except the habit sketches and the insects which were inked by the author.

PLATE 1

S. Burtii

Fig. 1. Surface view showing openings to tunnels, radiating ridges and depressions. × 4.

Fig. 2. Top layer removed exposing numerous healthy, non-parasitized scale insects. × about 11.

PLATE 1

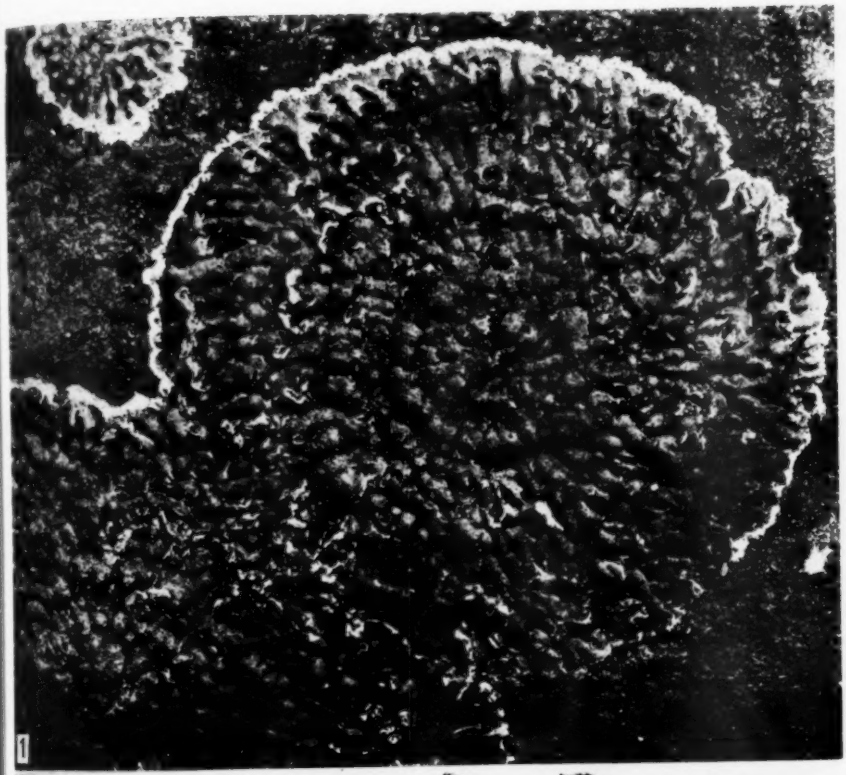

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PLATE 2

Figs. 1–5. *S. alni* Torrend. Figs. 1 and 2 on oak. Fig. 1, No. 8326. Fig. 2, No. 8323. Fig. 3. On *Hicoria pecan* enlarged about one third. Fig. 4. On oak. No. 8353. Fig. 5. A piece of type from Sydow.

Figs. 6 and 7. *S. alni* var. *squamosum* n. var. On oak. Fig. 6, No. 8323 (note *S. castaneum* on lower end of stick). Fig. 7, No. 8325.

Figs. 8 and 9. *S. Leprieurii* (Mont.) Pat. No. 8317. On *Magnolia virginiana*.

PLATE 2

PLATE 3

Figs. 1–5. *S. castaneum* Burt. Fig. 1, type. Slightly enlarged. Fig. 2. On *Ilex americana*. × about ½. Figs. 3, 4, 5, on *Quercus*. Figs. 3, 4, No. 8339. Fig. 5, No. 9152.

Figs. 6, 7. *S. Leprieurii* on *Magnolia virginiana*. In fig. 7 note large area of whitish crustose lichen. No. 9299.

PLATE 3

Plate 4

Figs. 1–5. *S. fumigatum* Burt.

Figs. 6–11. *S. Mariani* Brcs. Fig. 10, type. Figs. 6 and 8. On *Pyrus japonica*, spring condition; figs. 9 and 11 also on *P. japonica*, fall condition. In fig. 11 note young scale insects covered by round white pellicle. These hatched beneath fungus, crawling out to settle down on bark. Fig. 7. On *Liquidambar*. Figs. 9 and 11 × about 2½.

PLATE 4

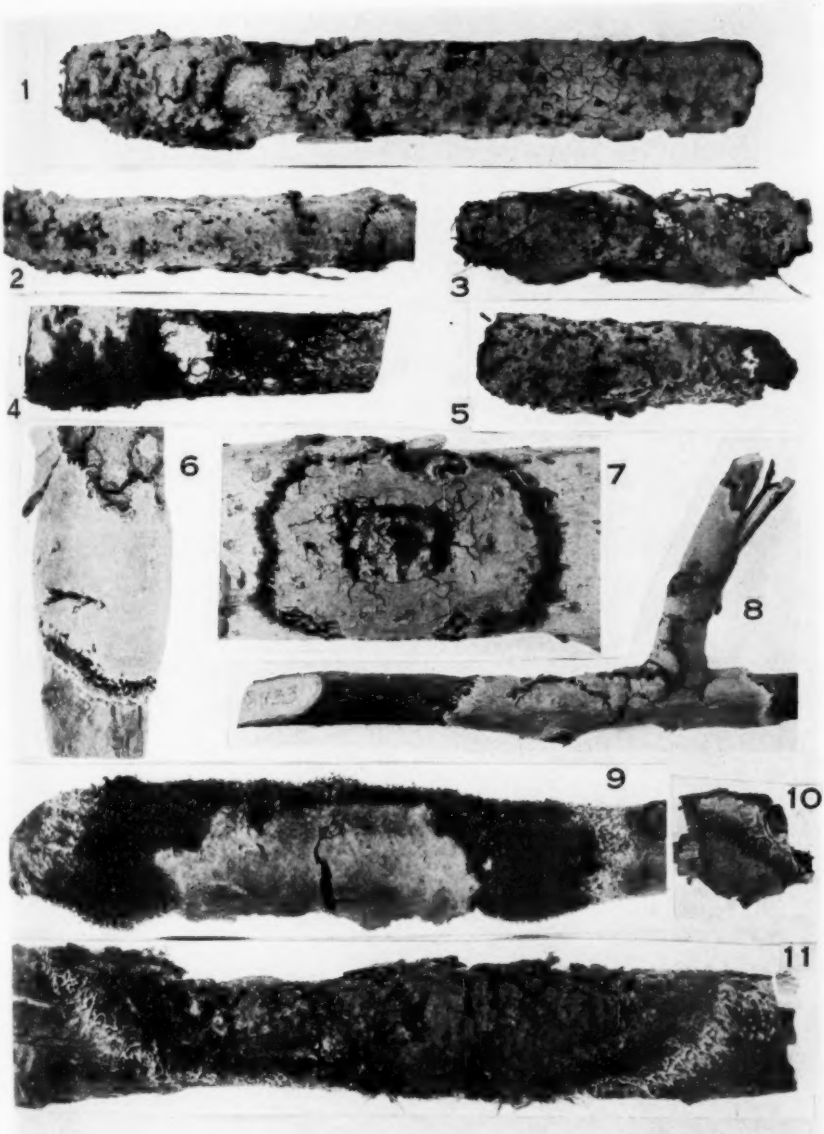

PLATE 5

Fig. 1. *S. grandisporum* n. sp., type. On *Cornus florida*. × about ½.
Fig. 2. *S. Curtisii* (B. & D.) B. & S. On *Nyssa* sp., causing witches' broom. × about ½.
Fig. 3. *S. Curtisii*. On *Fraxinus americana*. Photographed in August. Note whitish margin of new growth.
Fig. 4. *S. Curtisii* on *Fraxinus*. Early spring condition.
Fig. 5. *S. Burtii*, a variety with nearly smooth surface. On *Prunus*. × 2.
Figs. 6–8. *S. Sydowii* n. sp. From Philippine Islands, Elmer, coll., No. 14820. Type.

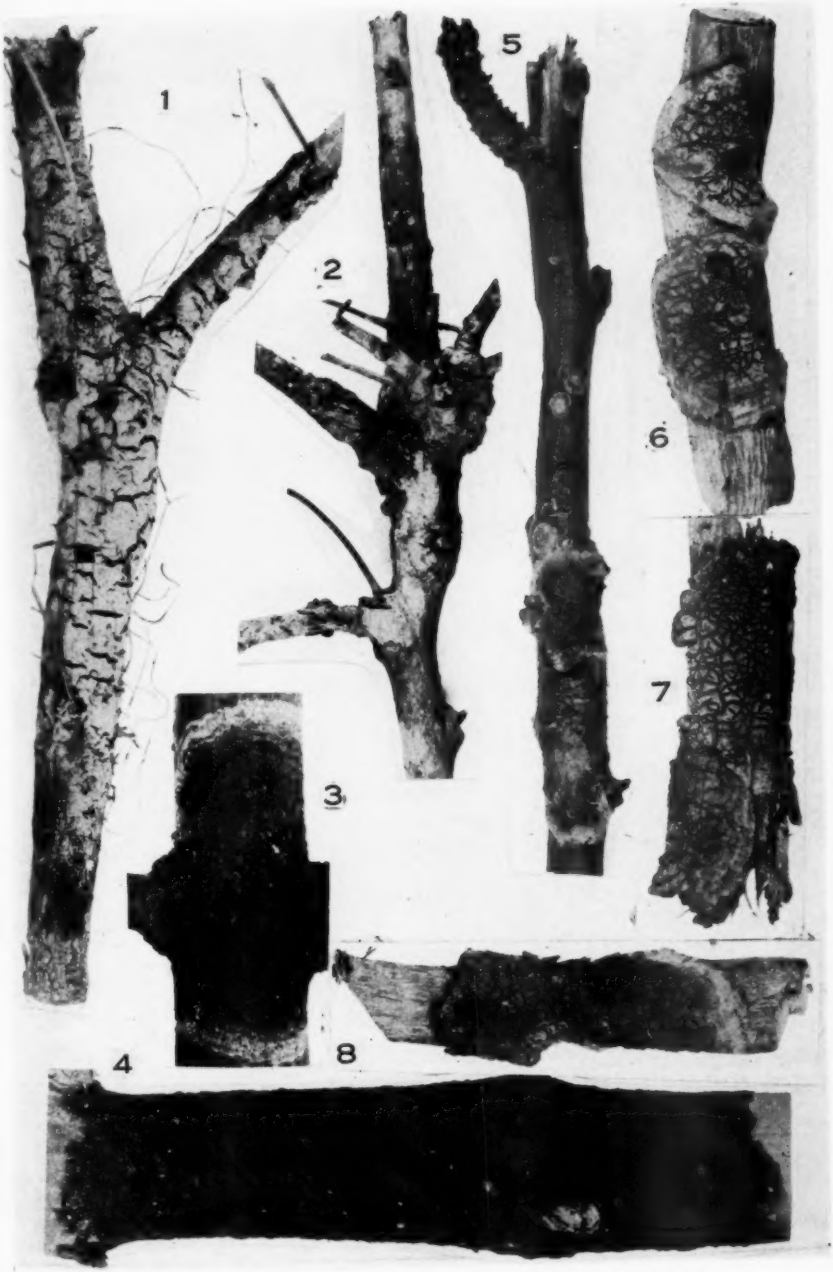
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PLATE 6

Figs. 1–12. *S. Carestianum* Bres. Fig. 1. On *Cornus sanguinea*, France. Patouillard, coll.

Figs. 2 and 3. On *Salix incana*. Leg. Otto Jaap. Fig. 11. Part of type. The others on *Cornus stolonifera* from Canada. John Dearness, coll.

Figs. 13 and 14. *S. lepidosaphis*. Fig. 13. Material from Cuba, sterile but apparently same as material shown in fig. 14 on *Citrus* from Florida.

Fig. 14. Slightly enlarged.

PLATE 6

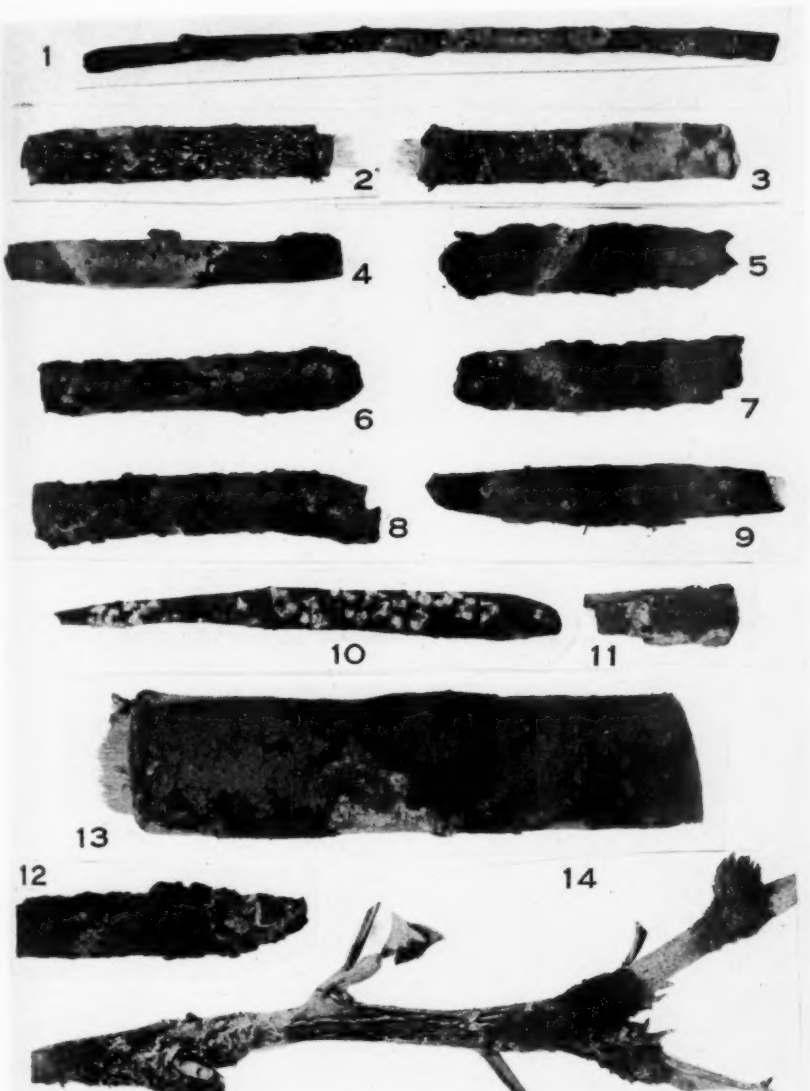


Plate 7

Figs. 1-7. *S. canescens* Burt.
Figs. 8, 9. *S. pilosum*. Fig. 8 from Florida on *Mangifera indica*; fig. 9, part of type from Java.
Figs. 10, 11. *Septobasidium* n. sp. conidial form on *Citrus* from Florida.
Figs. 12-14. *S. pinicola* Snell.

PLATE 7

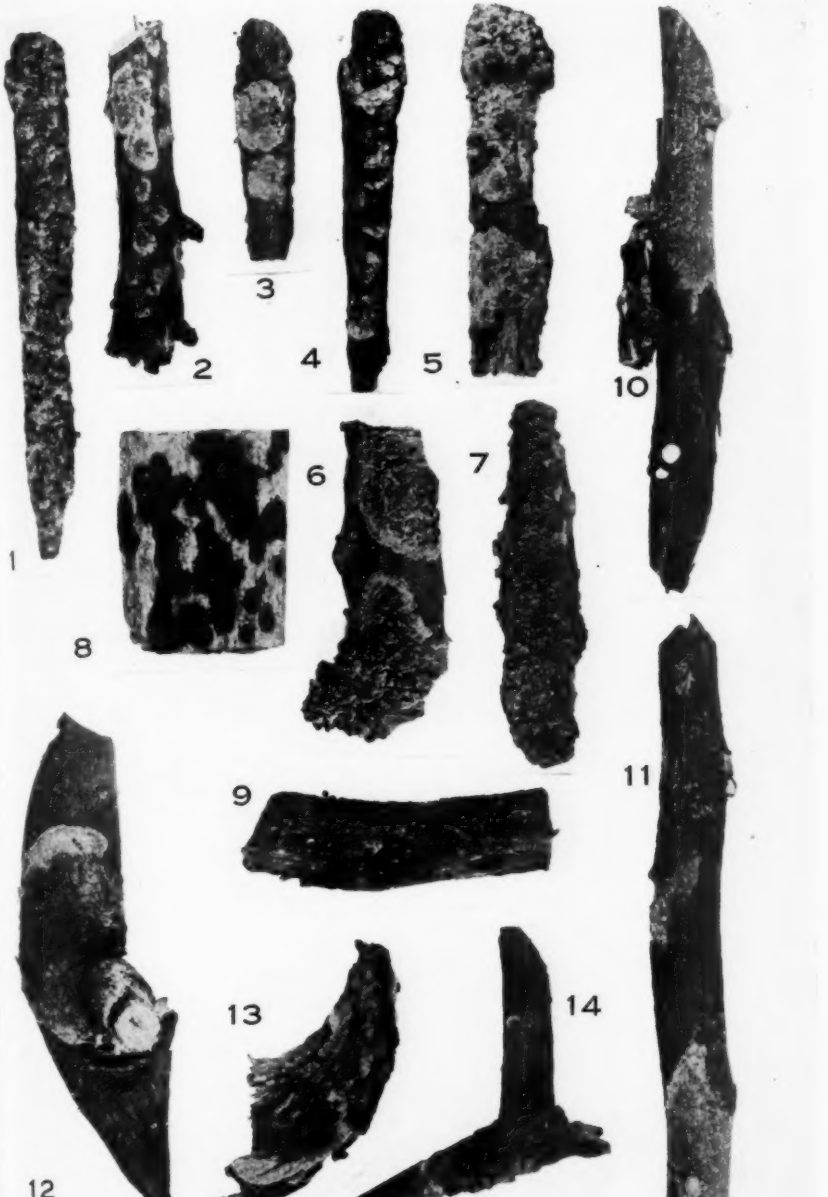


Plate 8

Figs. 1–3. *Septobasidium* sp. Close to *S. Langloisii*.
Fig. 4. *S. Langloisii* Pat. on *Magnolia virginiana* from Florida. × about $\frac{3}{4}$.
Figs. 5–7. *S. sinuosum* n. sp. Fig. 5, No. 9240; figs. 6, 7, No. 8475.

PLATE 8

Plate 9

Figs. 1–4. *S. tenue* n. sp. Black dots are elevated mounds each one covering a scale insect.

Figs. 5, 6. *S. rugulosum* n. sp. Fig. 5 × about 4. Fig. 6 × about 2. In both the black dots are depressed areas in each of which is a scale insect. Fig. 6 shows rugulose surface.

PLATE 9

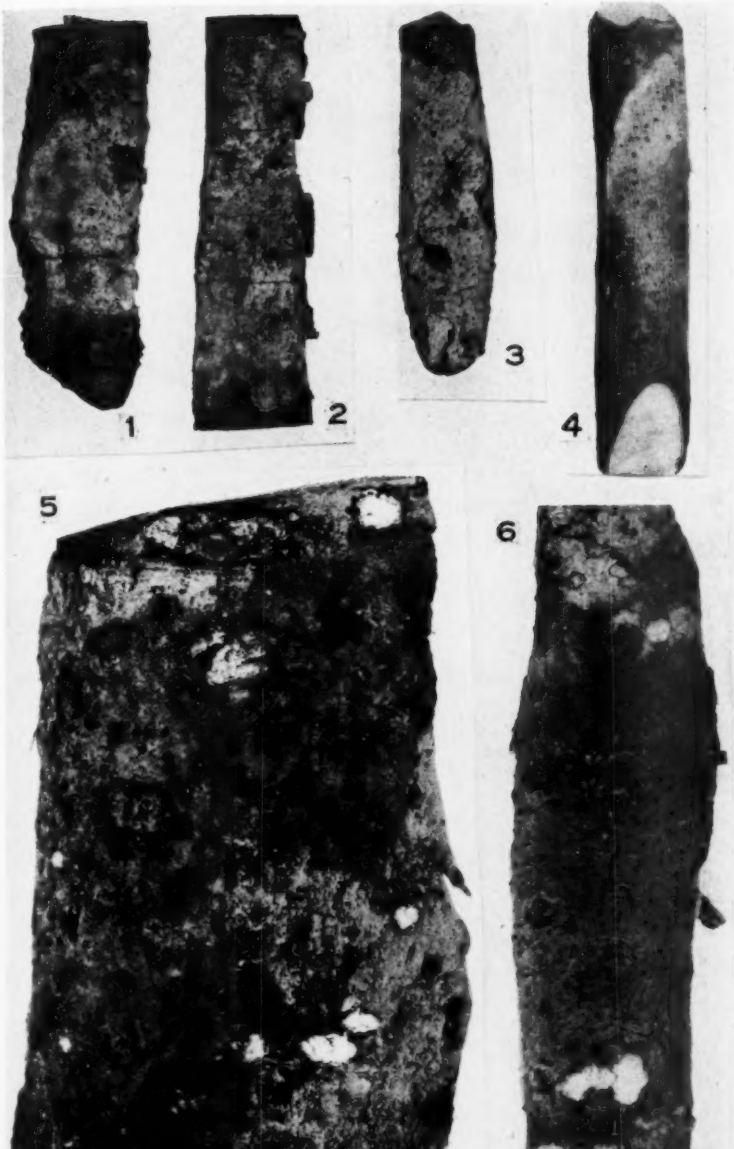


PLATE 10

S. pseudopedicellatum Burt

Fig. 1. Fragment of type showing whitish subiculum and dark top layer. Fig. 2. Small patch of growth on *Carpinus*, No. 9389. Figs. 3 and 4. On *Carpinus*, Oct. 23, 1932, No. 9325. Fig. 5. On *Carpinus*, May 14, 1933, No. 8389. Fig. 6. On *Cornus amomum*. Note white subiculum and rich brown shiny top surface. Fig. 7. Typical material on *Citrus* leaf, from Fla. F. A. Wolf, coll. Fig. 8 on *Citrus* twig, from Brazil. Azevedo, coll.

PLATE 10

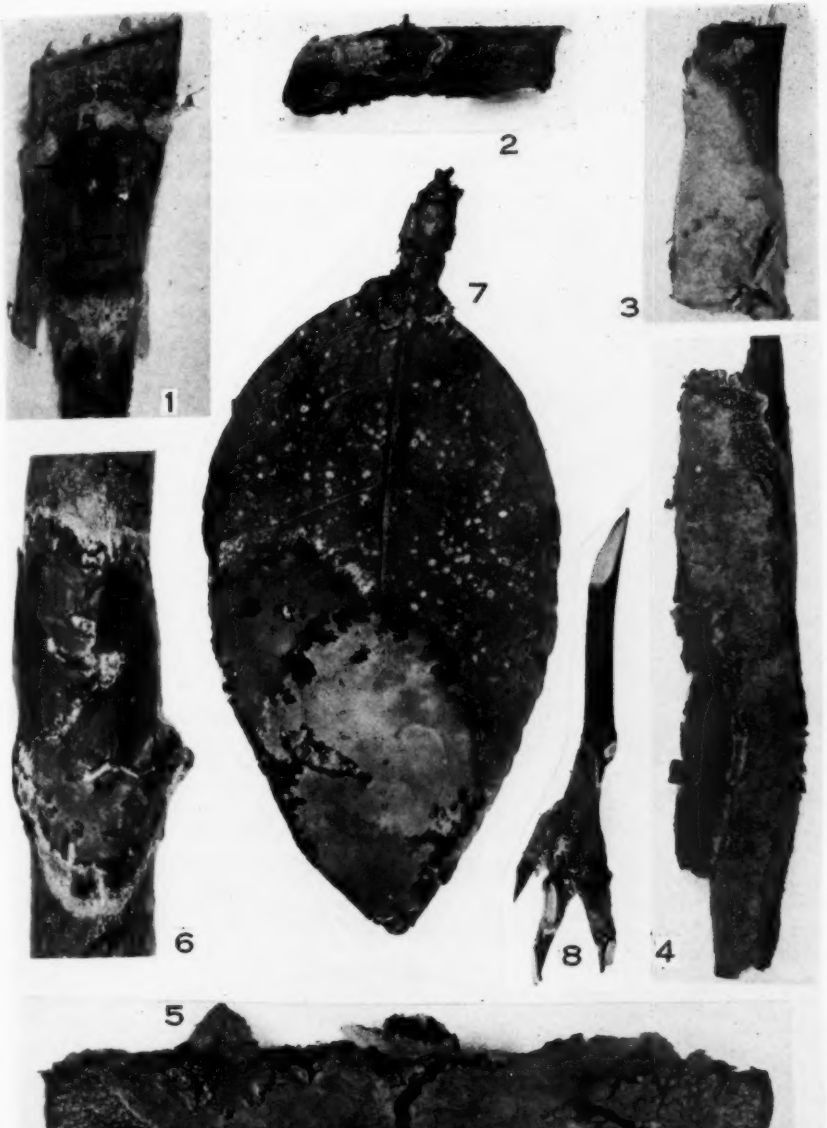


PLATE 11

S. pseudopedicellatum Burt

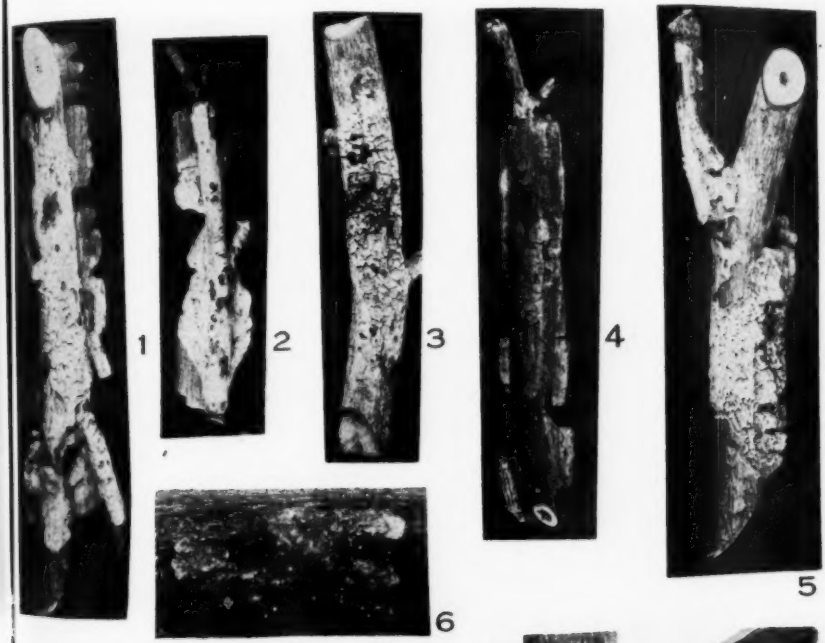
Figs. 1–3. Showing wood injury. Note *S. Schweinitzii* on lower right side of piece to left.

PLATE 11

PLATE 12

Figs. 1–5. *S. cremeum* n. sp. on *Liquidambar*.
Figs. 6–10. *S. apiculatum* n. sp.
Fig. 11. *S. leprosum* n. sp. Slightly reduced.

PLATE 12



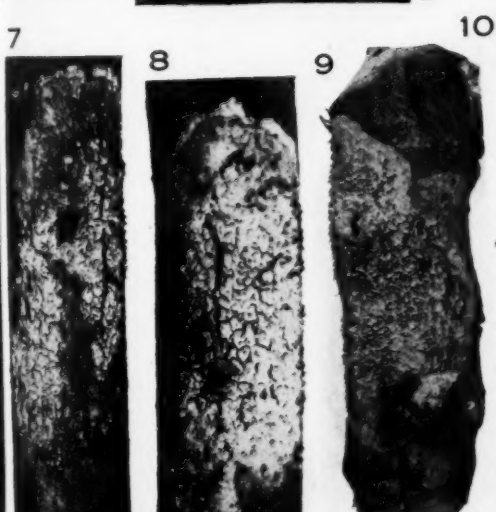


PLATE 13

Figs. 1–4. *S. Hesleri* n. sp.

Figs. 5–10. *Septobasidium* hybrid species between *S. pseudopedicellatum* and *S. Schweinitzii*. Fig. 6 also shows some *S. Patouillardii* Burt.

Figs. 11–13. *S. fuscum* n. sp. Note dark elevated mounds in 12 and 13.

PLATE 13

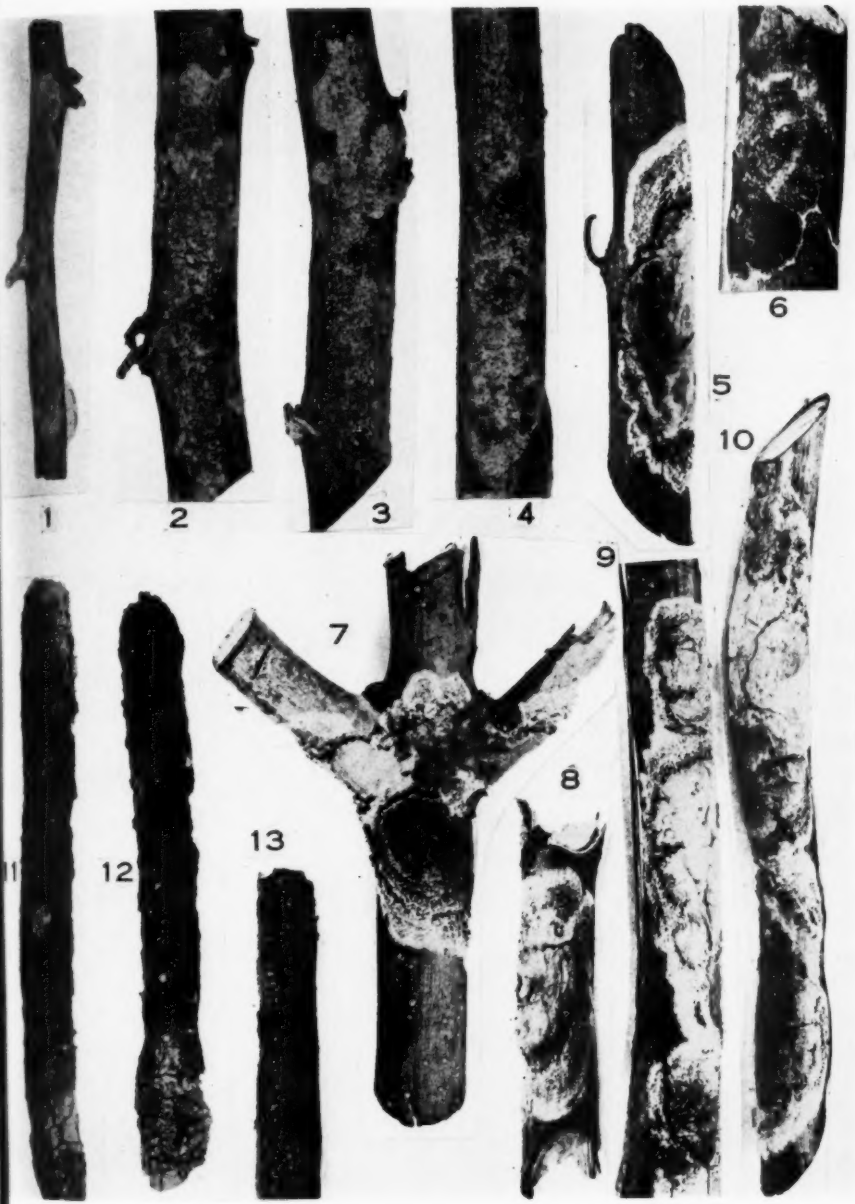


Plate 14

Fig. 1. *S. sabalis* n. sp. From Louisiana, Brown, coll. Type.
Fig. 2. *S. sabal-minor* n. sp. From Florida, Bomhardt, coll. Type.
Figs. 3, 4. *S.* n. sp. On pineapple leaf from Canal Zone, Weston, coll. Type (to be described later).

PLATE 14

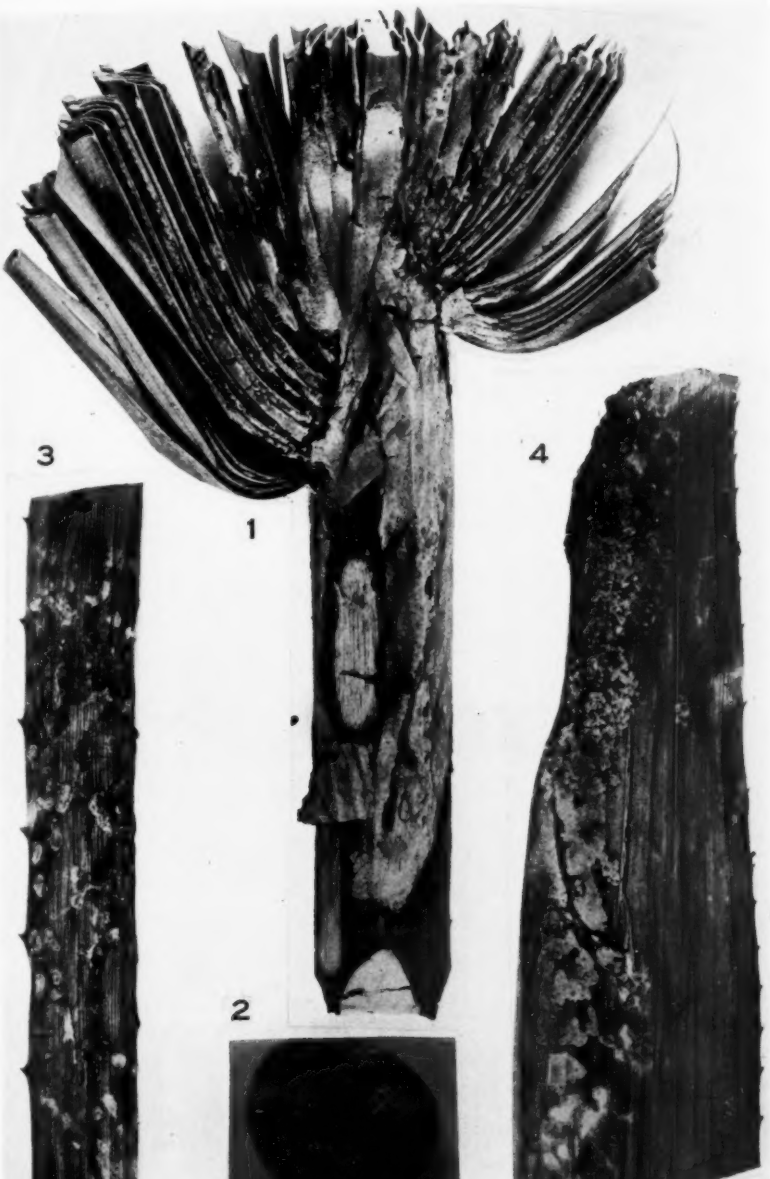


PLATE 15

Figs. 1–6. *S. Schweinitzii* Burt. Fig. 5 (below) *S. Schweinitzii*, (above) *S. pseudopedicellatum*. Fig. 6 shows enlarged (× about 5) view of margin with minute tent-like structures.

Figs. 7–11. *S. Patouillardii* Burt.

PLATE 15

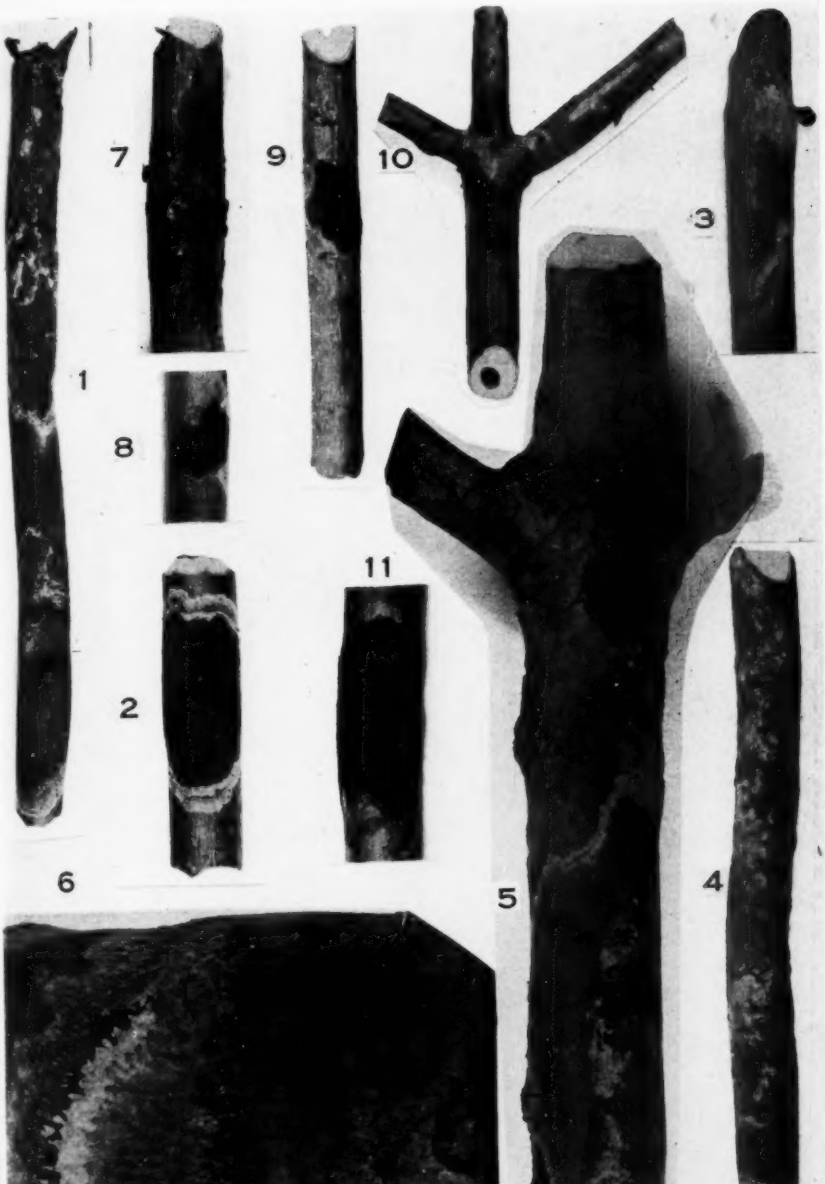


PLATE 16

Figs. 1–8. *S. filiforme* n. sp. Fig. 8 (above) *S. Cokeri,* (below) *S. filiforme.*
Figs. 9–13. *S. lilacinoalbum* n. sp. Fig. 11 shows margin. × about 4.

PLATE 16

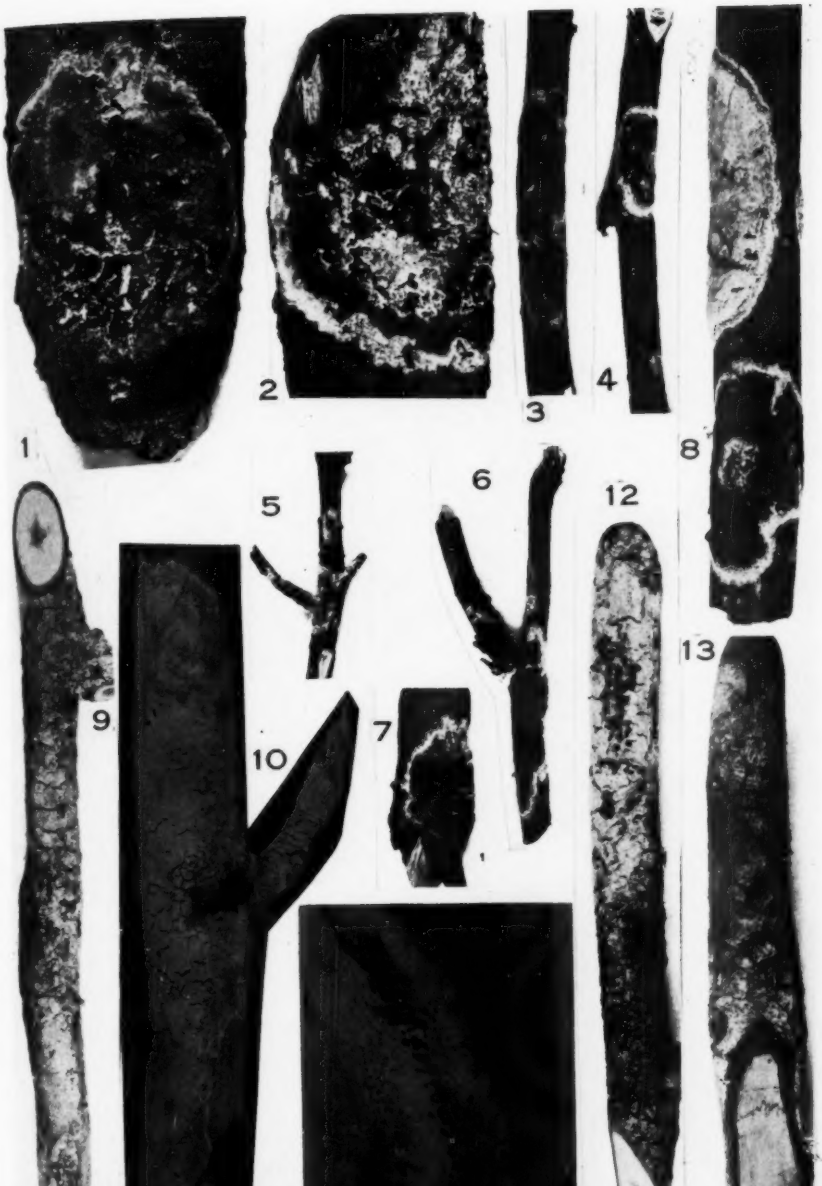


PLATE 17

Figs. 1–2. *S. Peckii* n. sp. × 1.5.
Figs. 3–6. *S. Cokeri* n. sp. Fig. 3 shows wood injury on dogwood.
Fig. 5. Section view showing subiculum, pillars, and top layer.
Fig. 6. Surface view of part of same specimen as shown in fig. 5. Figs. 5 and 6 × about 10. Both photographed in fresh condition. Note pure whiteness throughout.

PLATE 17

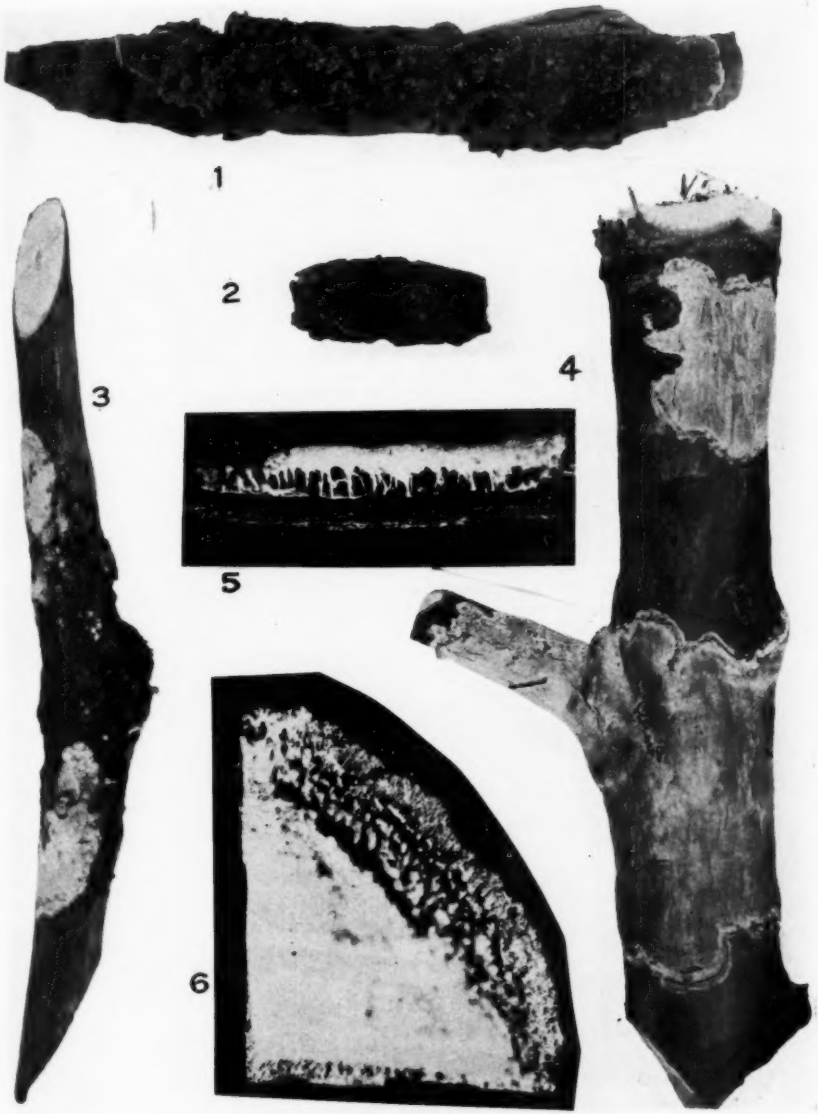


Plate 18

Figs. 1–8. *S. pilosum* B. & S.

Fig. 1. Diagram sketch through a tuft of growth, showing upright hyphae bearing conidia, and beneath the fungus in the center a parasitized scale insect. Note the coiled threads connecting insect with hyphal pad. × 18.

Fig. 2. Several upright hyphae bearing conidia. × 110

Figs. 3 and 4. Conidia. × 525.

Fig. 5. Thick-walled hyphae found in basal region. × 525.

Fig. 6. Haustoria from parasitized insect. × 525.

Fig. 7. Probasidia of type. × 525.

Fig. 8. Showing connection between haustoria and external thread. × 525.

Figs. 9–13. *S. pinicola* Snell.

Fig. 9. Sketch of section of *S. pinicola*, showing very irregular surface, parasitized and healthy insects. × 18.

Figs. 10 and 11. Basidia and spores. × 525 and × 580, respectively.

Figs. 12 and 13. Haustoria of "glomerulus" type. × 580.

Figs. 14–17. *S. Hesleri* n. sp.

Fig. 14. Sketch of margin showing a few scattered pillars arising from subiculum, several "insect houses" from one of which roof has been lifted, exposing insect. × 18.

Fig. 15. Hymenial section showing dichotomously branched paraphyses, coiled basidia, and spore. × 580.

Fig. 16. Spores, one of which has become septate, each septum forming a sterigma. × 580.

Fig. 17. Crystal-encrusted, upright threads from subiculum. × 335.

PLATE 18

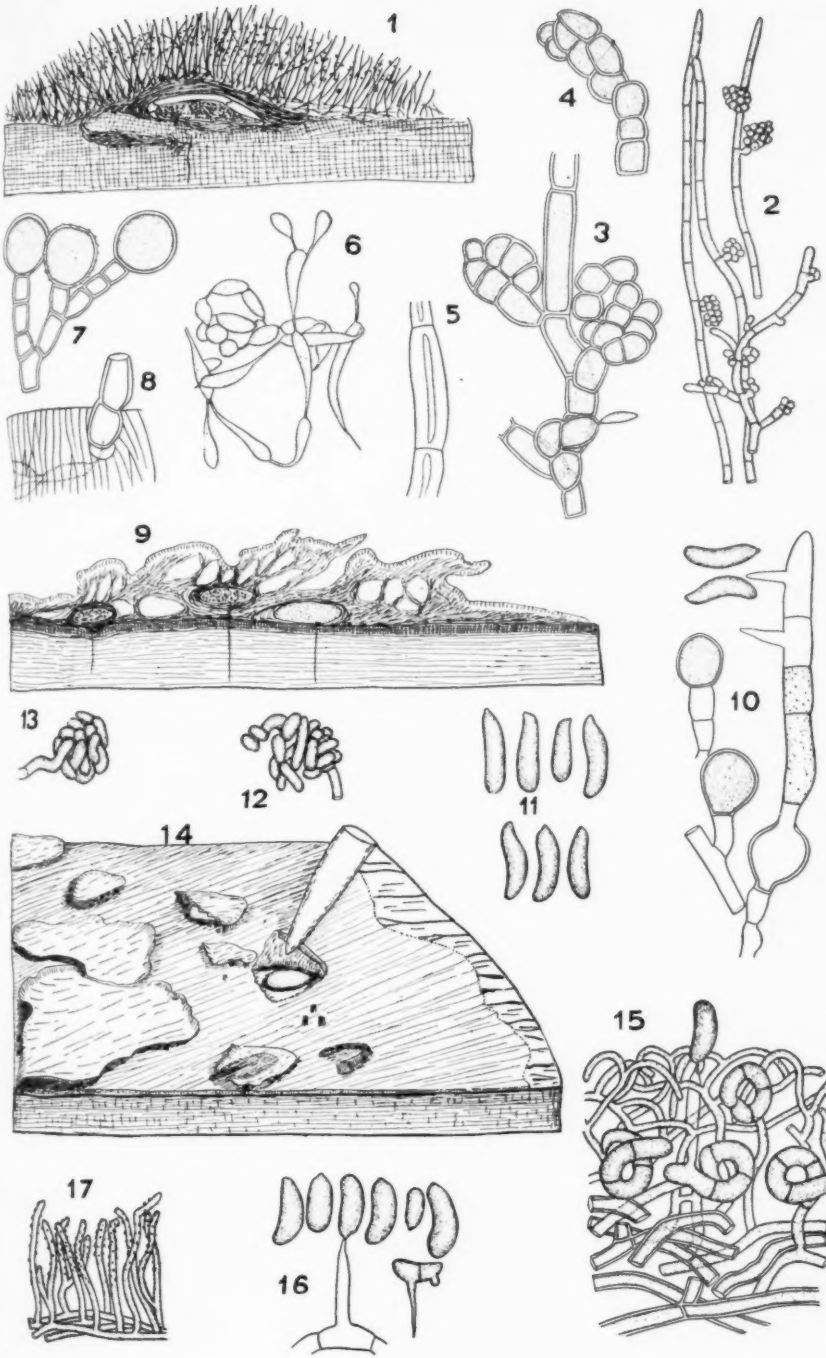


Plate 19

S. lepidosaphis n. sp.

Fig. 1. Sketch of marginal region, showing subiculum which in this species bears probasidia, basidia, and spores. Note anastomosing and branching pillars, top layer, and part of a scale insect. × 23.

Fig. 2. Spores. × 833.

Fig. 3. Large cells filled with protoplasm in subiculum. × 833.

Fig. 4. Surface view of subiculum showing hyphae, probasidia, basidia and spores on epidermis of leaf. × 833.

Fig. 5. Irregularly coiled haustoria. × 833.

Fig. 6. Adult healthy scale insect, *Lepidosaphes beckii*. × 100.

PLATE 19

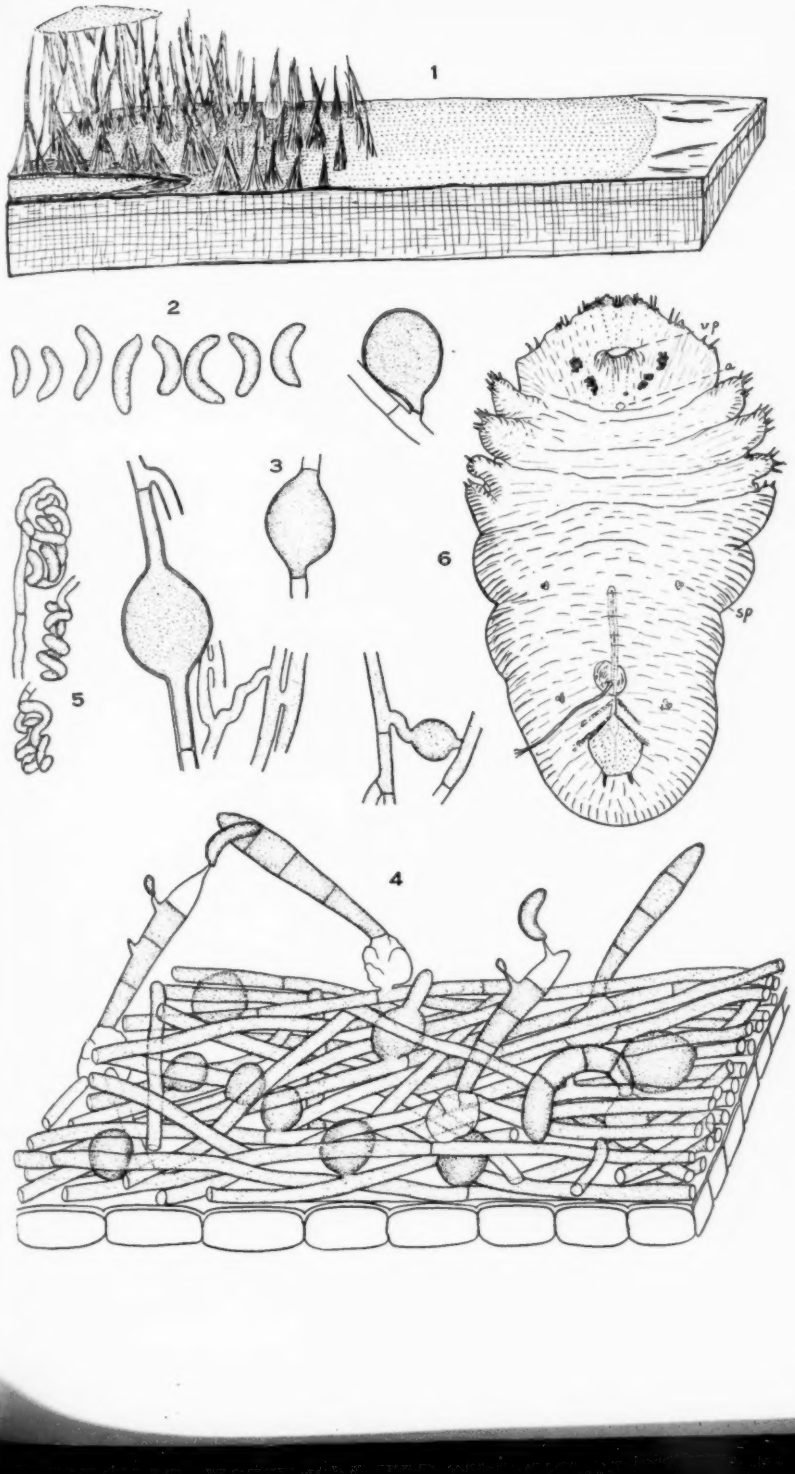


Plate 20

S. Carestianum Bres.

Fig. 1. Sketch showing section of hymenium, pillars, parasitized insect, and wood. × 33.

Figs. 2–7. Probasidia. Figure 5 also shows a thread from hymenial region. × 833.

Figs. 8 and 9. Basidia. × 833.

Fig. 10. Enlarged club-shaped bodies found in hymenial region in fall and winter. × 833.

Fig. 11. *Chionaspis corni* associated with *S. Carestianum*. This female was giving birth to young when collected. × 60.

Fig. 12. Section of hymenial region of young fertile plant in late spring. × 833.

Fig. 13. Empty probasidia showing club-shaped bodies growing through two probasidial cells. × 833.

Fig. 14. Haustoria. × 833.

PLATE 20

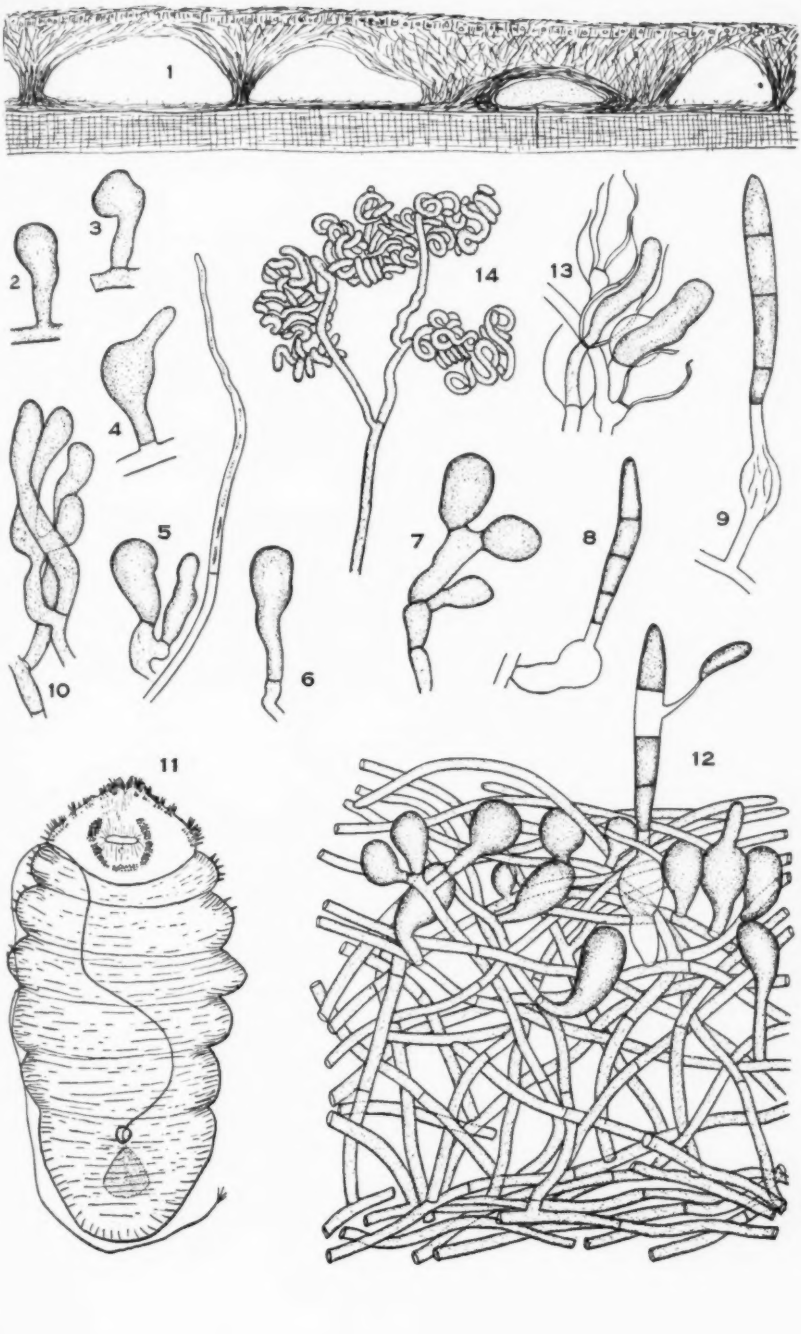


Plate 21

S. alni Torrend

Fig. 1. Section showing top layer with hymenium, pillars, one parasitized scale insect, and subiculum. No. 8325. × 33.

Fig. 2. Section of hymenium showing probasidia, basidia, and spores. No. 8326. × 833.

Fig. 3. Spores. No. 8326. × 833.

Figs. 4–7. Empty probasidia, showing proliferation. Torrend, coll. In New York Bot. Gard. Herb. No. 373. × 833.

Figs. 8–10. Empty and proliferating probasidia. Type from Sydow, No. 68. × 833.

Figs. 11 and 12. Empty probasidia. From Georgia, Higgins, coll., No. 8498. × 733.

Fig. 13. Proliferating probasidium (?). N. Y. Bot. Gard. Herb. No. 373. × 833.

Fig. 14. Haustoria. × 833.

PLATE 21

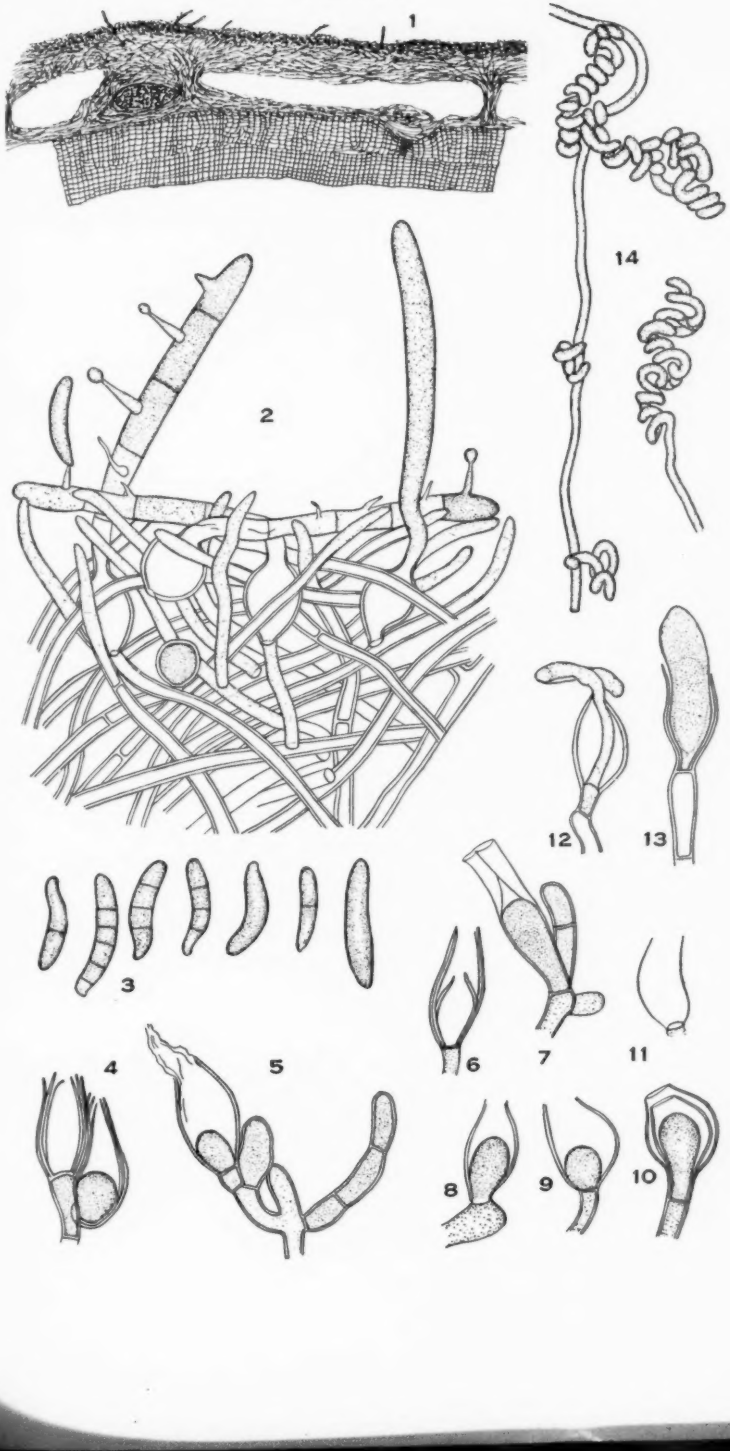


PLATE 22

S. sabal-minor n. sp.

Fig. 1. Sketch through outer part of fruit of *Sabal minor* showing fungus covering scale insect. × 38.
Fig. 2. Hymenium showing probasidia and basidia. × 938.
Figs. 3–7. Probasidia and basidia. × 938.
Fig. 8. Spores. × 938.
Fig. 9. Haustorium. × 938.

PLATE 22

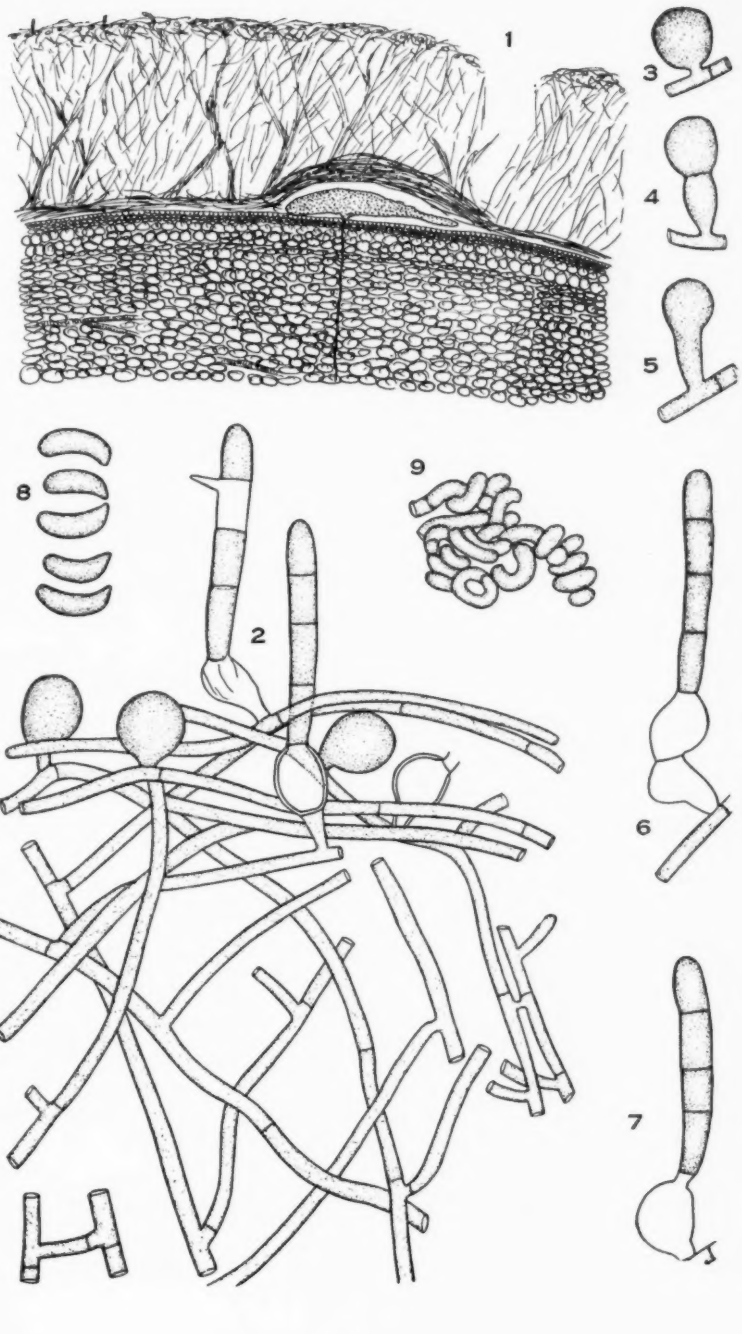


Plate 23

S. fumigatum Burt.

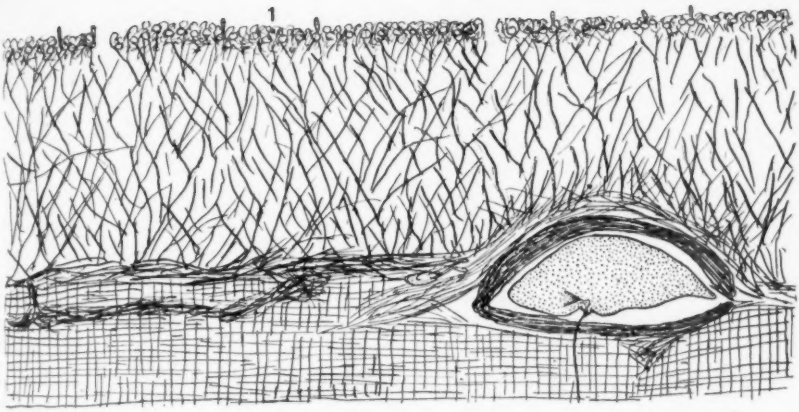
Fig. 1. Section showing hymenium, context, and subiculum, also a scale insect. × 33. Fig. 2. Hymenium, with coiled paraphyses, probasidia, basidia, and spores. No. 8458. × 833.

Fig. 3. Three basidia of type material. × 833.

Fig. 4. Basidium of material from Alabama. Mo. Bot. Garden Herb. No. 20068. × 833.

Fig. 5. Haustoria within *Aspidiotus tenebricosus* on *Cornus florida* from Florida. × 833.

PLATE 23



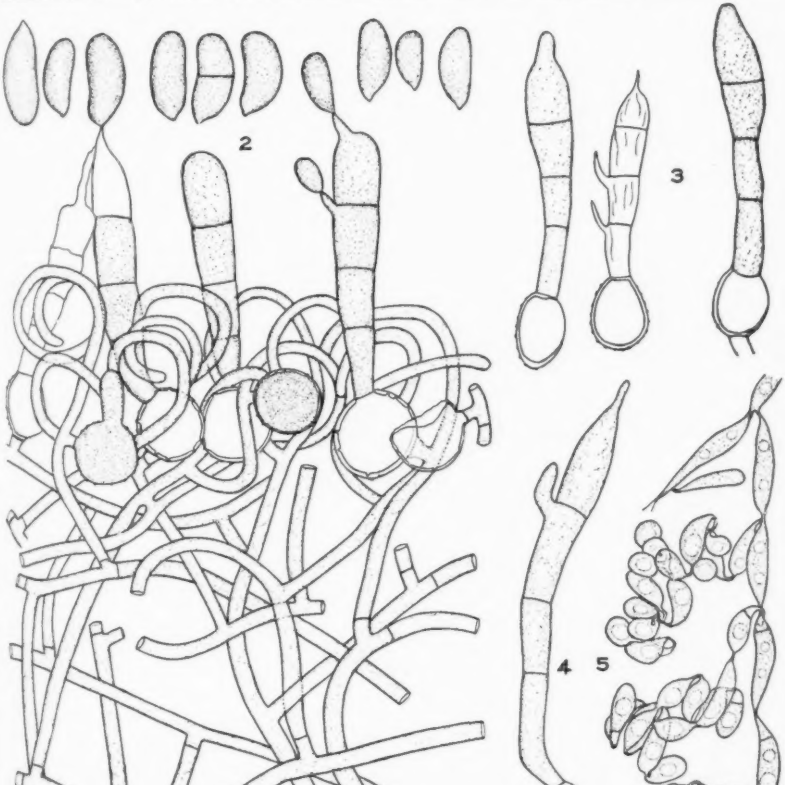


Plate 24

S. fuscum n. sp.

Fig. 1. Section showing fertile region and thick tufts of upright hyphae over insects. × 33.

Fig. 2. Enlarged section showing subiculum and hymenium with recurved paraphyses, probasidia, basidia, and spores. × 833.

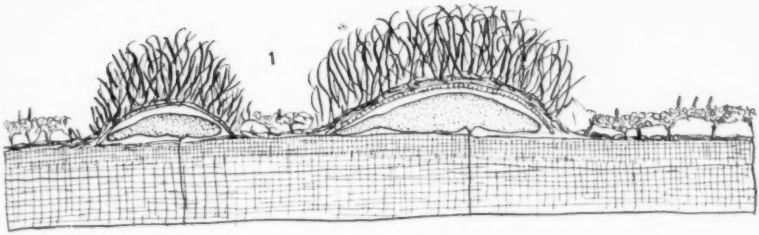
Fig. 3. Spores. × 833.

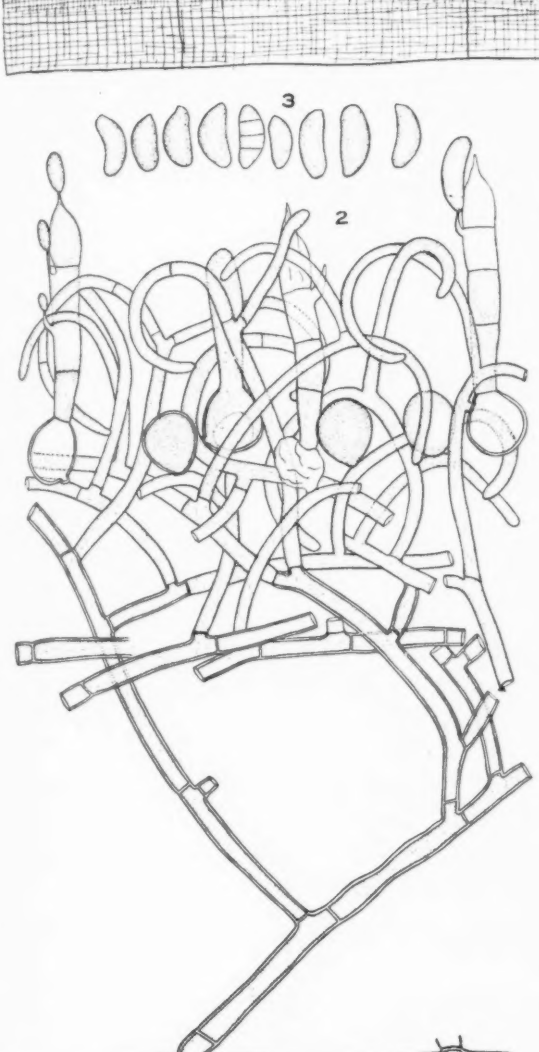
Fig. 4. Haustoria. × 833.

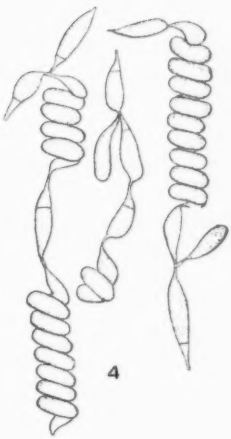
Fig. 5. View of parasitized insect in spiracular region showing a fungal coil surrounded by chitinous material. A connection is shown between coil and external hyphae passing through dermal pore. × 833.

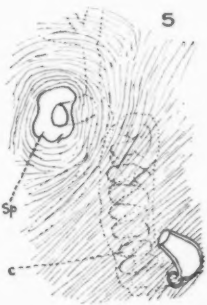
Fig. 6. Showing how fungal pad may overgrow part of insect. × 833.

PLATE 24









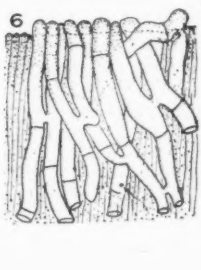


Plate 25

Figs. 1–3. *S. castaneum* Burt.

Fig. 1. Sketch of type showing very irregular marginal condition. Stubby pillars and three horizontal layers are shown in places, also note scale insects. × 9.

Fig. 2. Hymenial region showing probasidia and basidia. × 833.

Fig. 3. Spores. × 833.

Fig. 4. *S. alni* var. *squamosum* n. var. Sketch showing surface and sectional view. × 18.

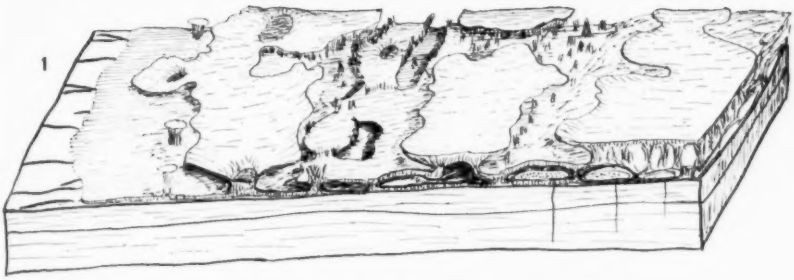
Figs. 5–7. *S. Leprieurii* (Mont.) Pat.

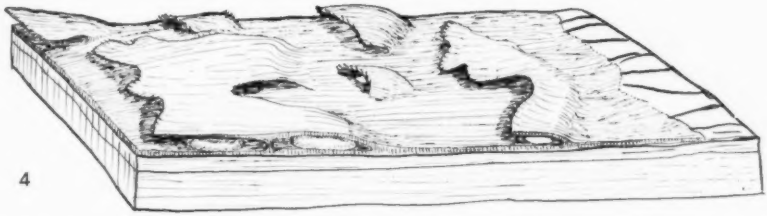
Fig. 5. Section showing stratification of fungus, the top stratum being fertile with mature basidia. Note parasitized scale insect. × 33.

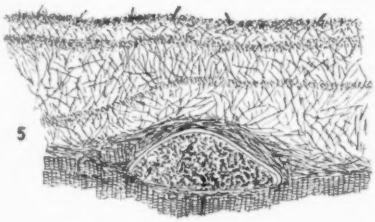
Fig. 6. Section of hymenium showing probasidia, basidia, and spores. × 833.

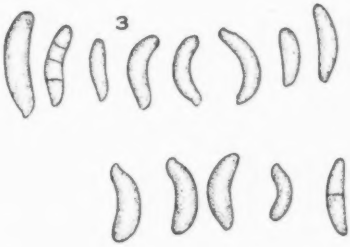
Fig. 7. Spores. × 833.

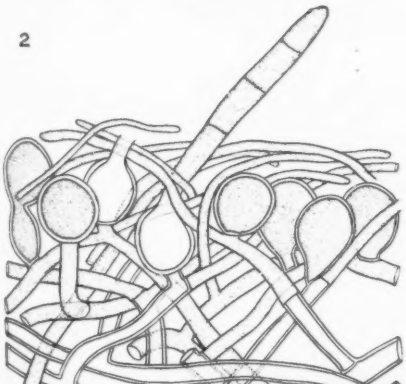
PLATE 25











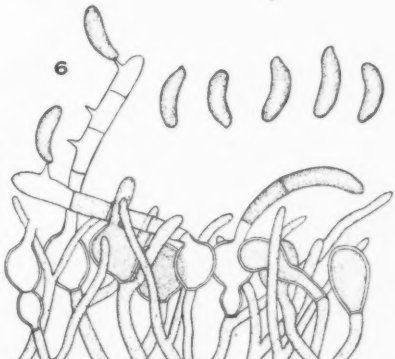


PLATE 26

S. Mariani Bres.

Fig. 1. Section showing three vertical layers of fungus, the hymenial surface showing probasidia and basidia. Note branched and anastomosing pillars also parasitized scale insect beneath fungus. × 33.

Fig. 2. Anastomosing pillars. × 833.

Fig. 3. Section through hymenial region showing probasidia and basidia. × 833.

Fig. 4. Probasidia and basidium. × 833.

Fig. 5. Spores. × 833.

PLATE 26

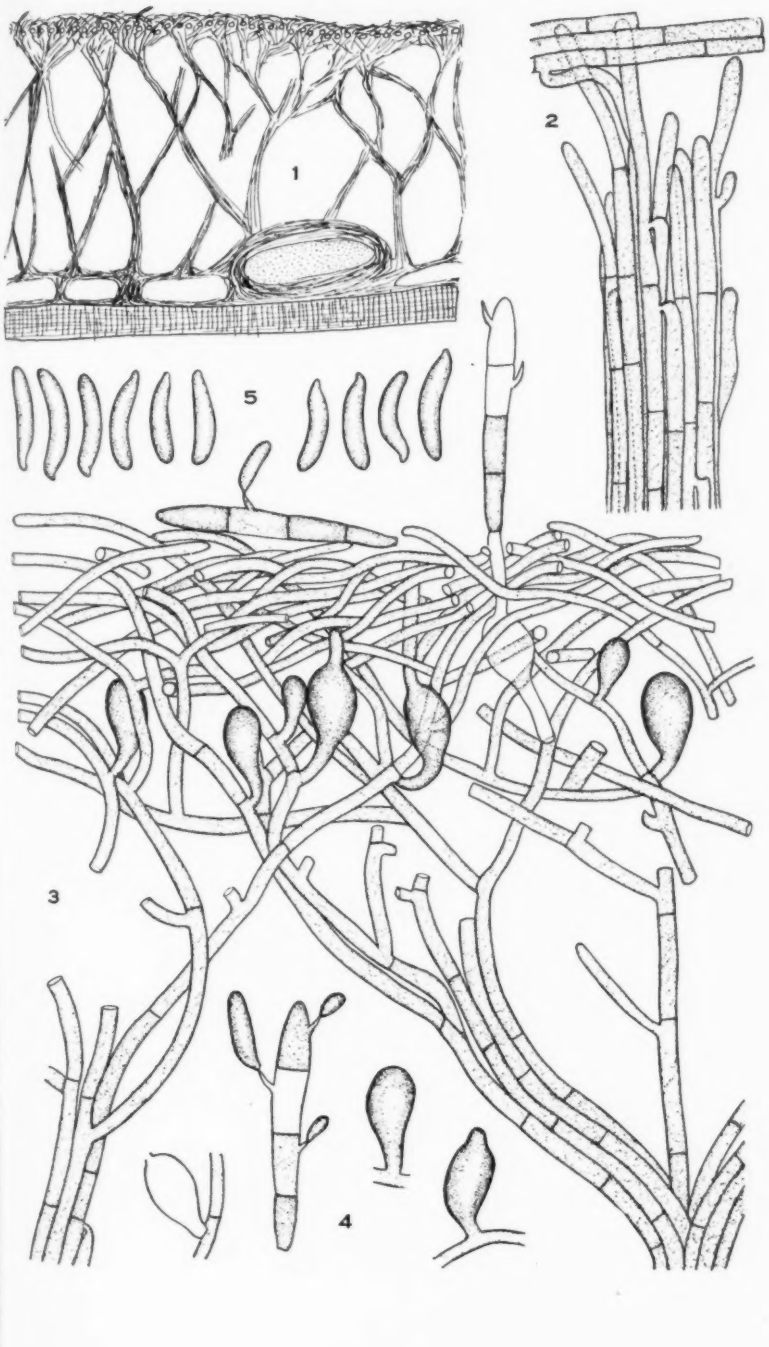


PLATE 27

S. pseudopedicellatum Burt.

Fig. 1. Sketch showing subiculum, pillars, and top layer. Note tuft of short threads at base of pillars. × 18.

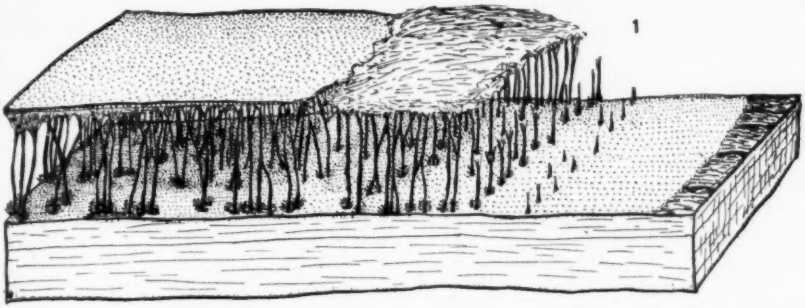
Fig. 2. Section through hymenium showing probasidia, basidia, spores, and paraphyses. At left are two probasidial cells each of which has formed one basidium and into which new probasidia have proliferated. Type. × 700.

Fig. 3. Spores. Above on *Carpinus*, No. 9389, from North Carolina; below on *Citrus* from Brazil, Müller, coll., No. 9722. × 700.

Fig. 4. Spores. On *Fraxinus*. No. 8401. × 833.

Figs. 5 and 6. Various shapes and sizes of basidia. × 833.

PLATE 27



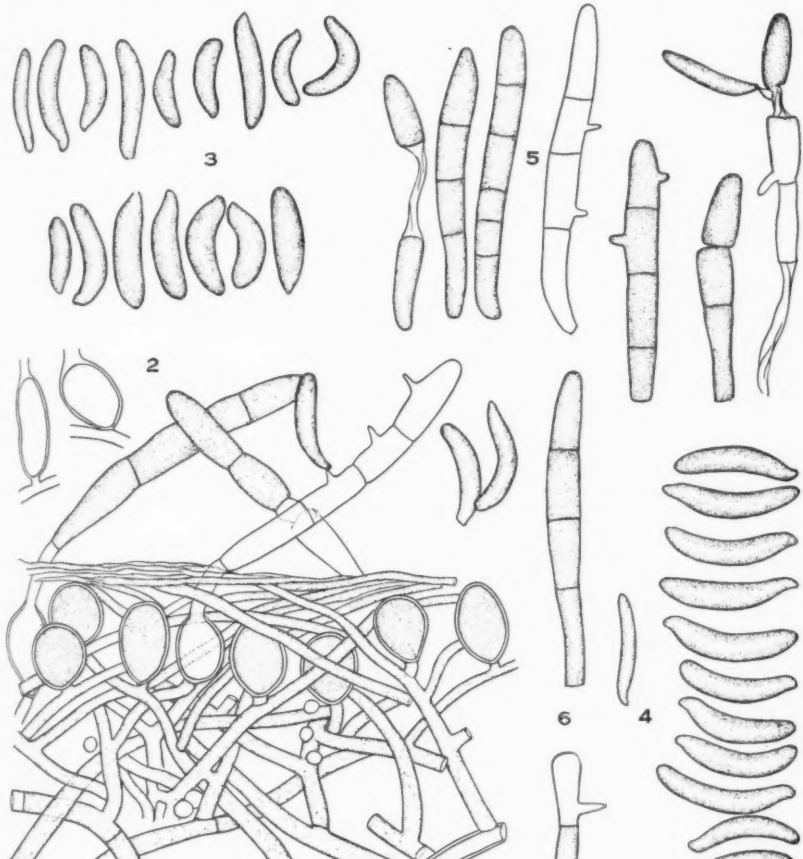


PLATE 28

S. Burtii Lloyd

(= *S. retiforme* sense of American authors but not Patouillard.)

Fig. 1. Section of hymenium showing probasidia, basidia, and spores. × 938.

Fig. 2. Spores showing two types of budding. The four to left show close type of budding, the other four show open type of budding. × 938.

Fig. 3. Hyphae and bud cells on agar. × 938.

Fig. 4. Germination on agar of coiled haustoria. × 825.

PLATE 28

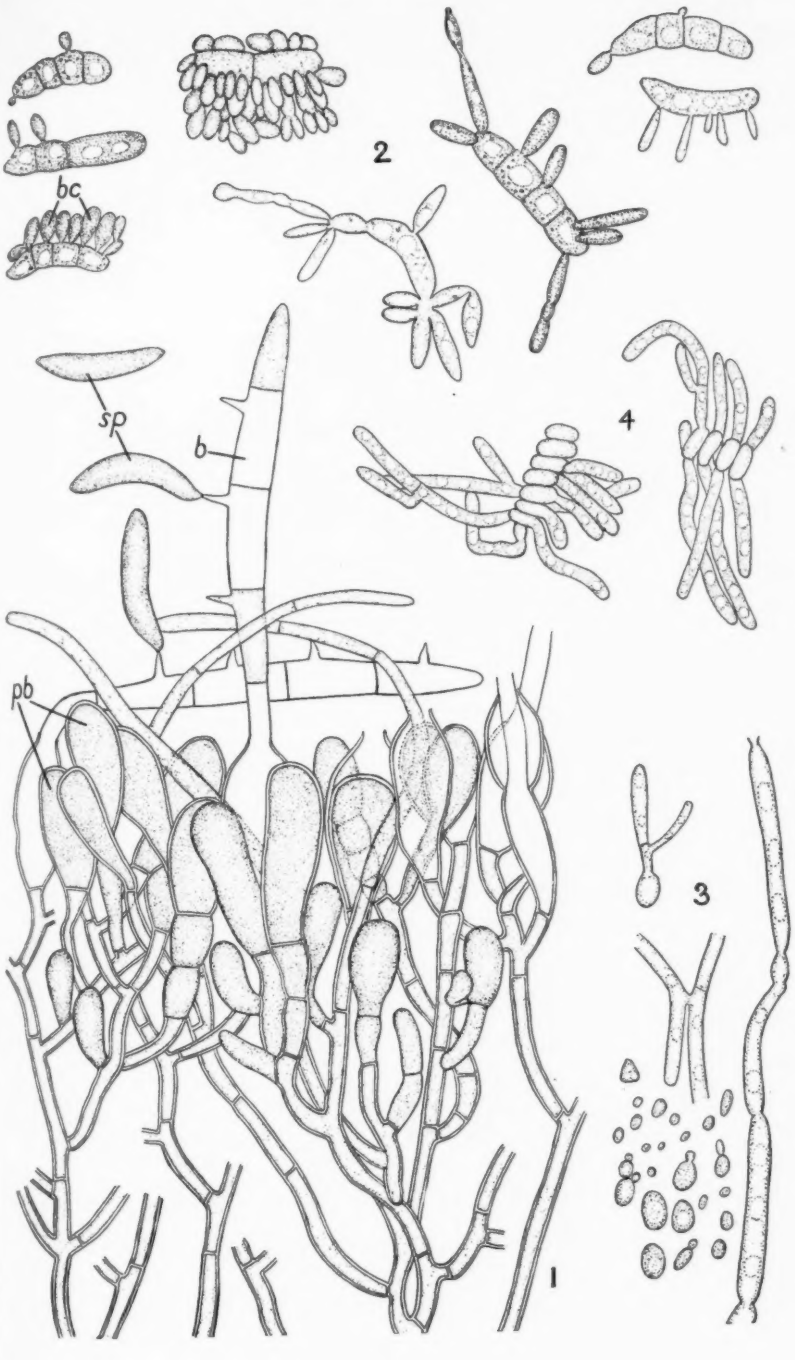


Plate 29

Figs. 1–3. *S. sinuosum* n. sp.

Fig. 1. Hymenium showing probasidia, basidia, spores, and paraphyses. × 833.

Fig. 2. Basidia of Mo. Bot. Gard. Herb. No. 44211. × 833.

Fig. 3. Segments of haustoria from parasitized insects. × 833.

Figs. 4 and 5. *S. leprosum*.

Fig. 4. Section through hymenium, context, and subiculum showing probasidia, basidia, and spores. × 533.

Fig. 5. Spores. × 833.

PLATE 29

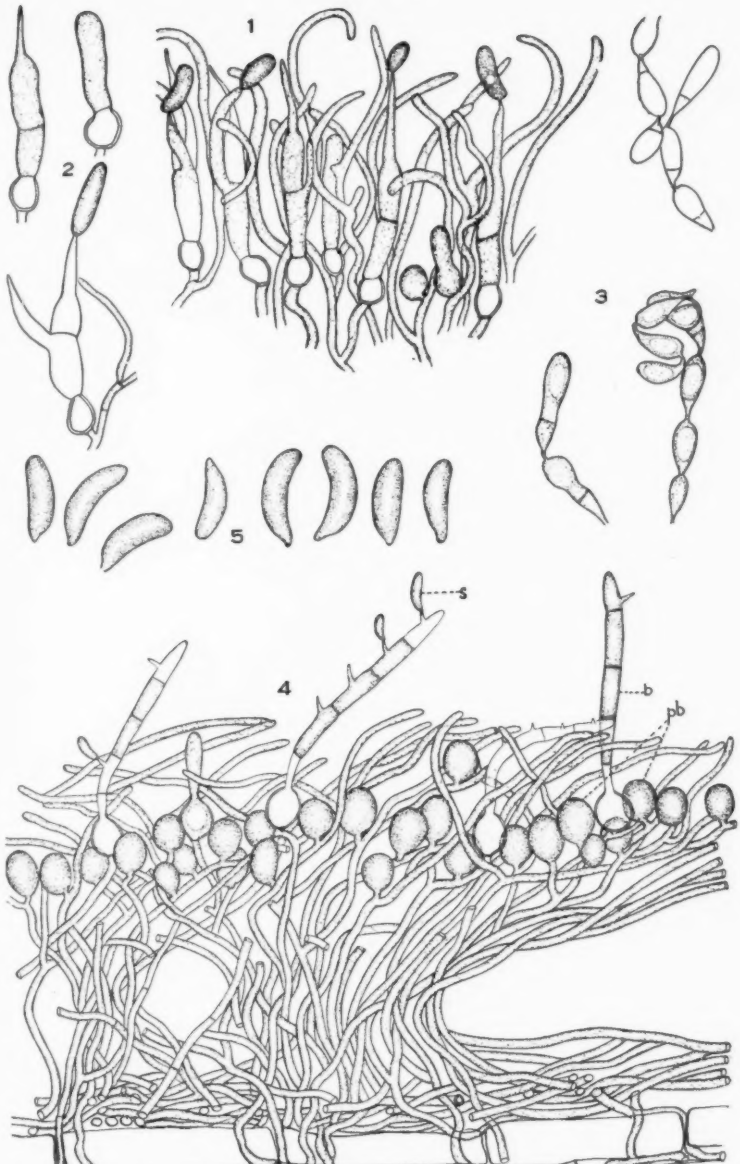


PLATE 30

S. Sydowii n. sp.

Fig. 1. Section through fungus showing compact context and stratified hymenium. × 33.

Fig. 2. Section of hymenium showing probasidia, coiled basidia and spores. Also note old collapsed probasidial cells at base of hymenium. × 833.

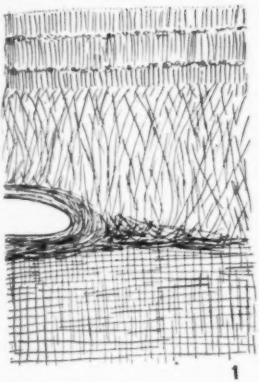
Figs. 3–5. Basidia. × 833.

Fig. 6. Spores. × 833.

Fig. 7. Haustoria. × 833.

Fig. 8. Anal segment of scale insect associated with *S. Sydowii*. × 233.

PLATE 30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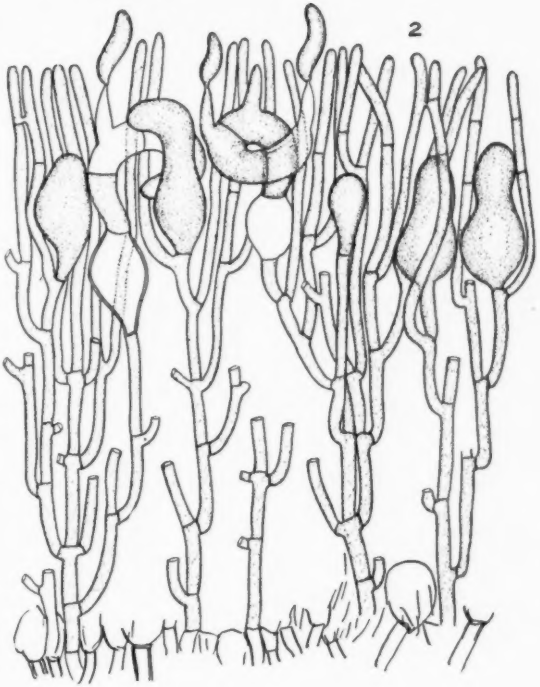
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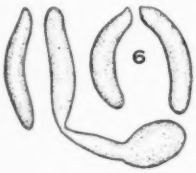
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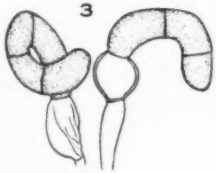
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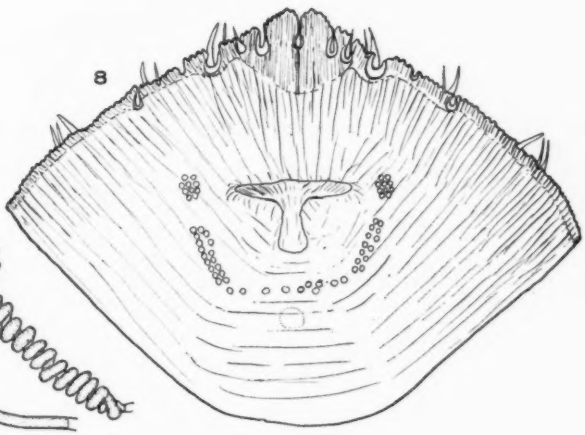
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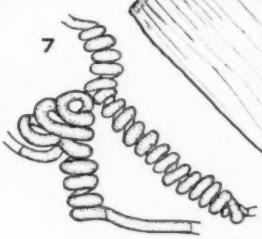
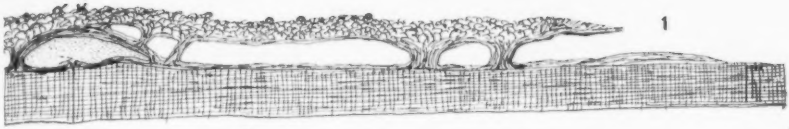

7

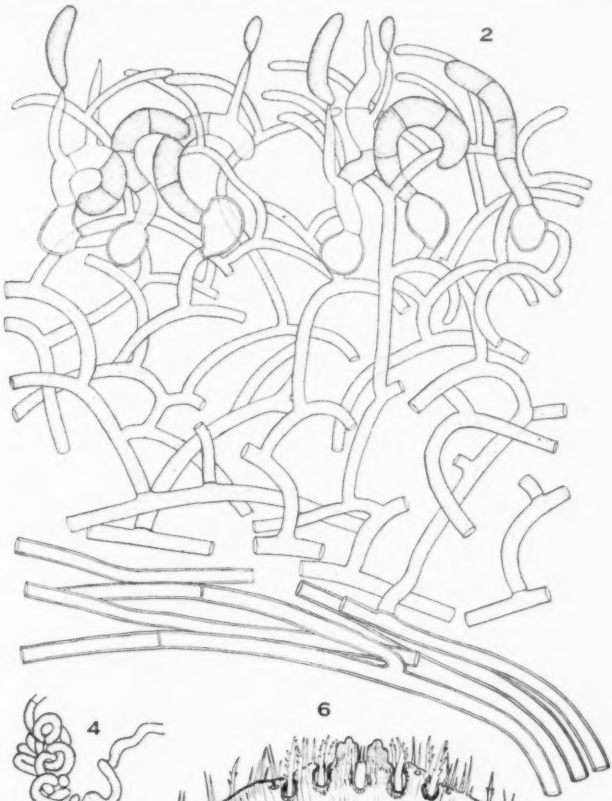
Plate 31

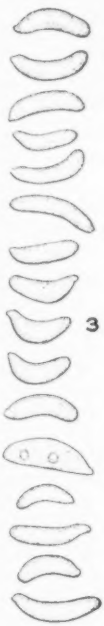
S. cremeum n. sp.

Fig. 1. Section through marginal region of fungus showing hymenium with basidia, pillars, subiculum and one scale insect. × 33.
Fig. 2. Hymenial region, showing empty probasidia, basidia, spores, and paraphyses.
Fig. 3. Spores. × 833.
Fig. 4. Haustorium from parasitized insect. × 833.
Fig. 5. *Aspidiotus liquidambaris* Kot. × 60.
Fig. 6. Anal segment of same scale insect, ventral surface. × 233.

PLATE 31







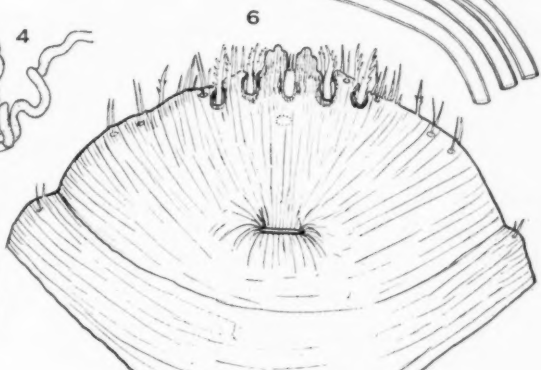


PLATE 32

S. filiforme n. sp.

Fig. 1. Section of fungus showing hymenium, pillars, subiculum, and three insects. × 33.

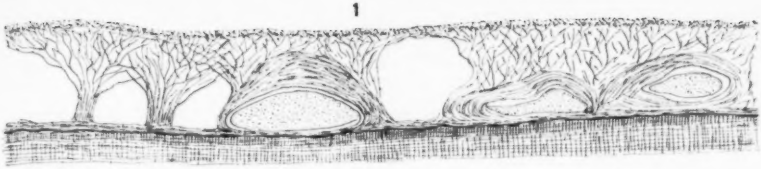
Fig. 2. Hymenium with probasidia, basidia, and very narrow threads which frequently break up into short bacilliform segments. × 847.

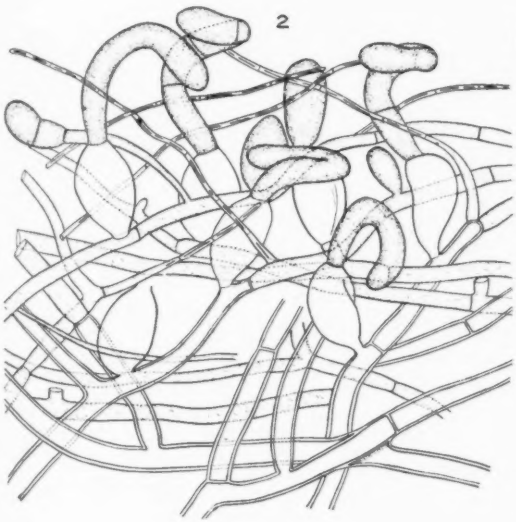
Fig. 3. Young basidia.

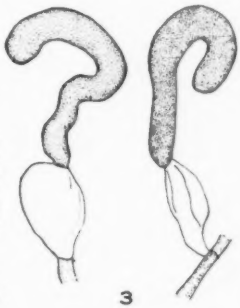
Fig. 4. Mature basidia and spores. × 833.

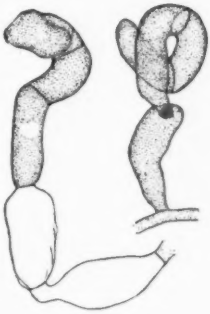
Fig. 5. Haustoria. × 833.

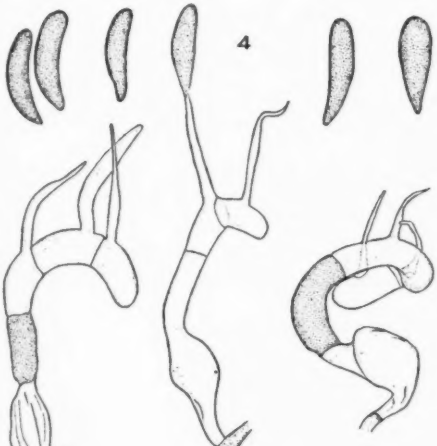
PLATE 32











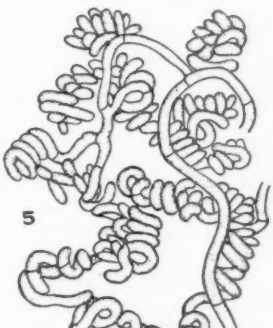


PLATE 33

S. Schweinitzii Burt.

Fig. 1. Section of fungus showing hymenium, pillars, subiculum and parasitized insects. No. 5876. × 33.

Figs. 2 and 3. Basidia bearing spores. × 847.

Figs. 4–8. Probasidia (?) and resting basidia. Type material. × 833.

Fig. 9. Hymenium showing upright thick-walled paraphyses, basidia and spores. Coll. March 14, 1929. No. 8397.

Fig. 10. Hymenium showing resting, coiled, septate basidia (?). Coll. Dec. 28, 1921. × 833.

Fig. 11. Spores. × 833.

PLATE 33

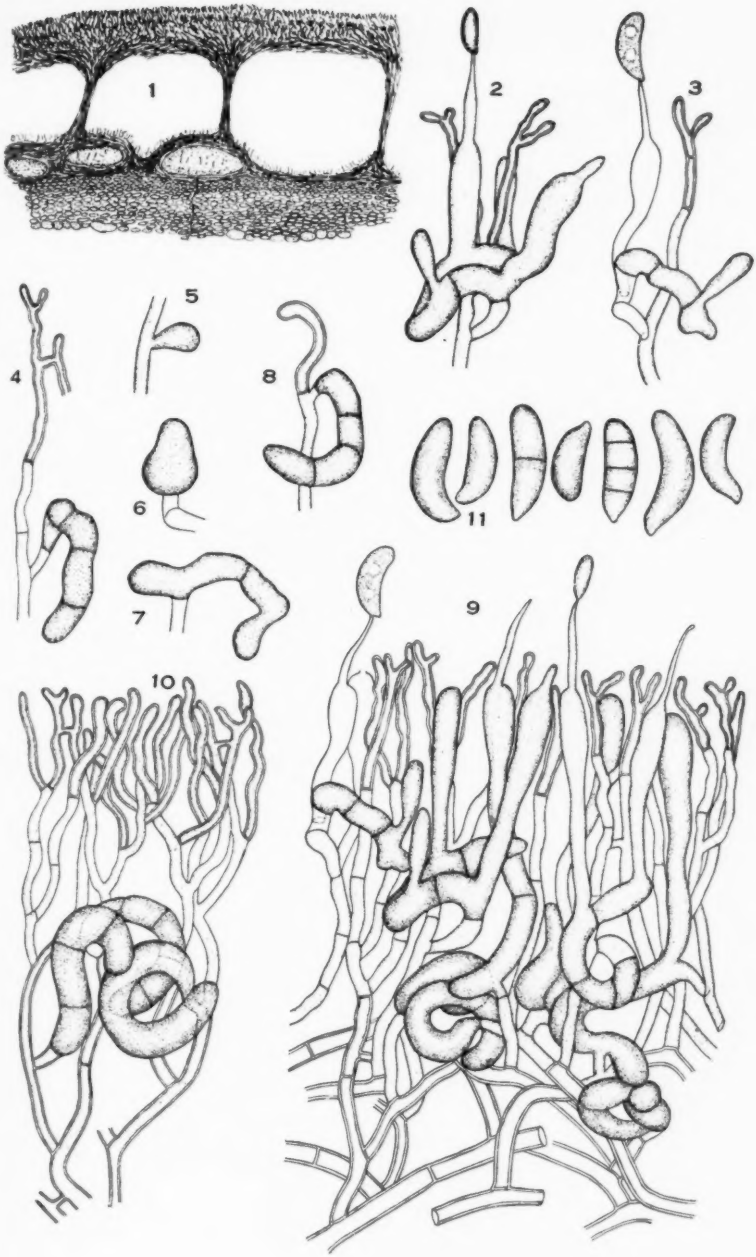


Plate 34

S. lilacinoalbum n. sp.

Fig. 1. Section of fungus showing hymenium, pillars, subiculum and two scale insects. × 33.

Fig. 2. Hymenium with basidia, spores, and paraphyses. Note numerous anastomoses between paraphyses. × 833.

Fig. 3. Probasidia (?) and basidia. × 833.

Fig. 4. Spores. × 833.

Fig. 5. Paraphyses. × 833.

Fig. 6. Segment of hypha showing protoplasmic connection between cells. × 833.

Fig. 7. Haustoria. × 833.

Figs. 8 and 9. *Chionaspis gleditsiae* Sanders (?), the scale associated with this fungus. Fig. 8 × 60; fig. 9 × 233.

PLATE 34

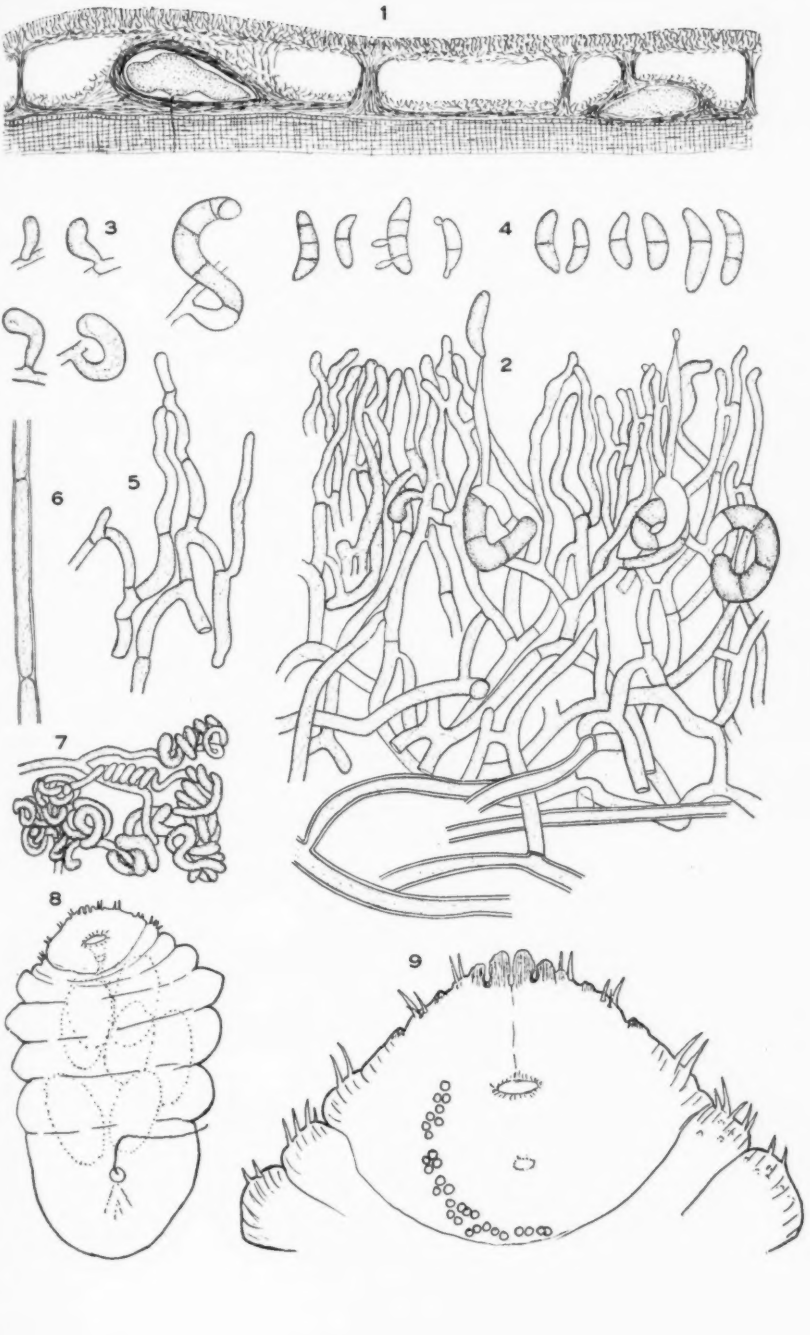


PLATE 35

Hybrid between *S. pseudopedicellatum* Burt and *S. Schweinitzii* Burt.

Fig. 1. Sketch of marginal region of hybrid showing "tents," which are characteristic of *S. Schweinitzii* Burt and "pillars" characteristic of *S. pseudopedicellatum* Burt. × 16.

Fig. 2. Hymenium of *S. pseudopedicellatum* Burt showing typical probasidia, basidia and paraphyses. × 750.

Fig. 3. Hymenium of hybrid, showing paraphyses characteristic of *S. Schweinitzii* and probasidia and basidia combining characters of both parents. × 696.

Figs. 4–10. Stages in development of basidia of hybrid. × 750.

PLATE 35

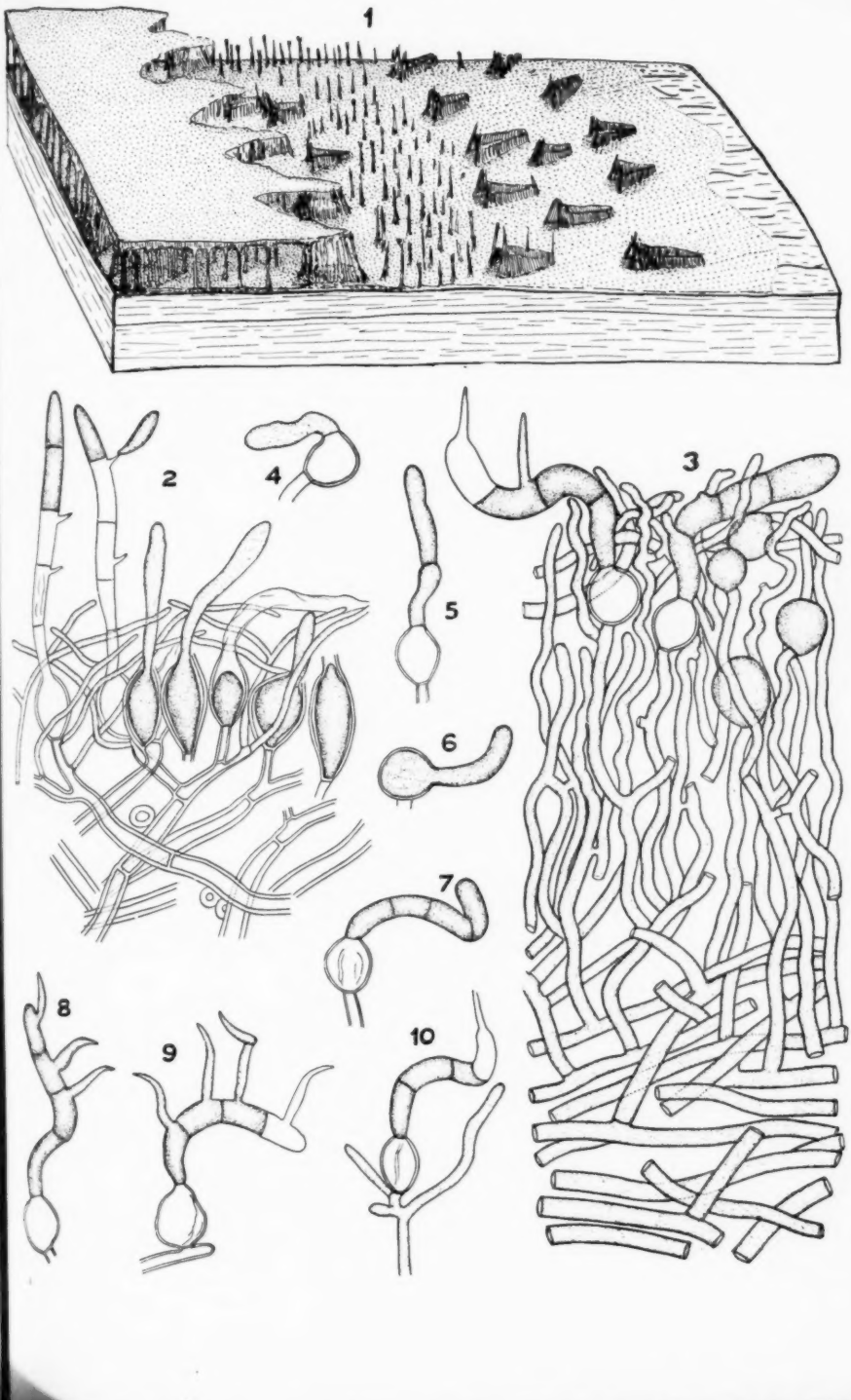


Plate 36

S. rugulosum n. sp.

Fig. 1. Section of fungus, marginal region. × 50.

Fig. 2. Section showing context and hymenial region with recurved, crystal encrusted paraphyses and basidia. No. 9251. × 938.

Fig. 3. Spores. No. 8472. × 938.

Figs. 4–10. Basidia, all of No. 8472 except fig. 9 (No. 9151). × 938.

Fig. 11. Hyphal segments of context separated by crushing under a cover slip. × 938.

Fig. 12. Associated scale insect, *Chionaspis gleditsiae* (?). From No. 9229. × 68.

PLATE 36

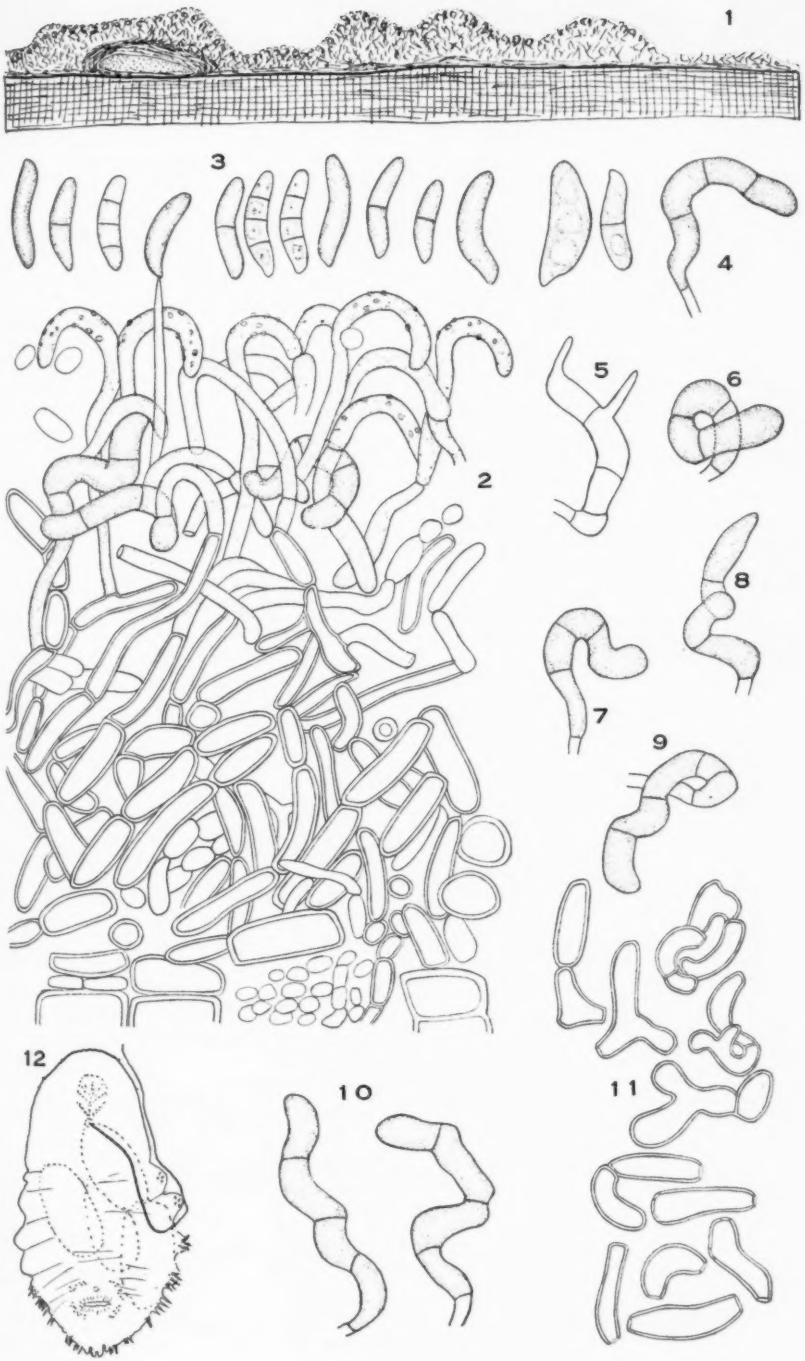


Plate 37

S. tenue n. sp.

Figs. 1 and 2. Sections of fungus. Fig. 1, No. 9154; fig. 2, No. 9183. × 33.

Fig. 3. Section of context and hymenial region showing basidia and spores, paraphyses with crystal encrusted tips. Note algal cells. Also note that hyphae of context are not broken up into short segments. × 833.

Fig. 4. Spores, below of No. 8456, above of No. 9154. × 833.

Figs. 5–9. Basidia. × 833.

Fig. 10. Haustoria from parasitized scale insect. No. 8456. × 833.

PLATE 37

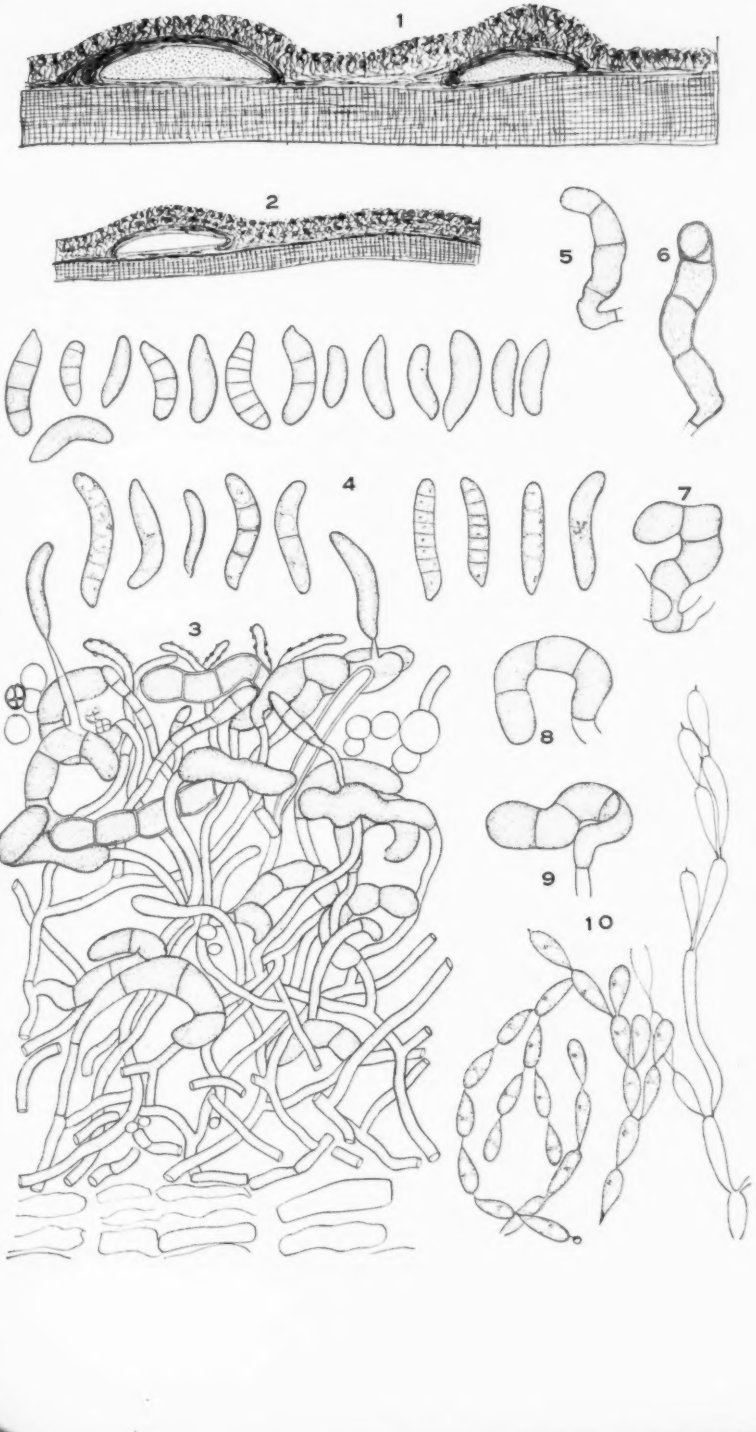


Plate 38

S. canescens Burt.

Fig. 1. Sketch of section through marginal region of fungus, showing hymenium with probasidia and basidia, context, and one parasitized insect. × 33.

Fig. 2. Section of hymenial region showing probasidia, basidia, paraphyses, and algal cells. × 833.

Figs. 3–6. Basidia. × 553.

Fig. 7. Spores. × 553.

Fig. 8. Haustorium of "glomerulus" type. All figures from type material. × 833.

PLATE 38

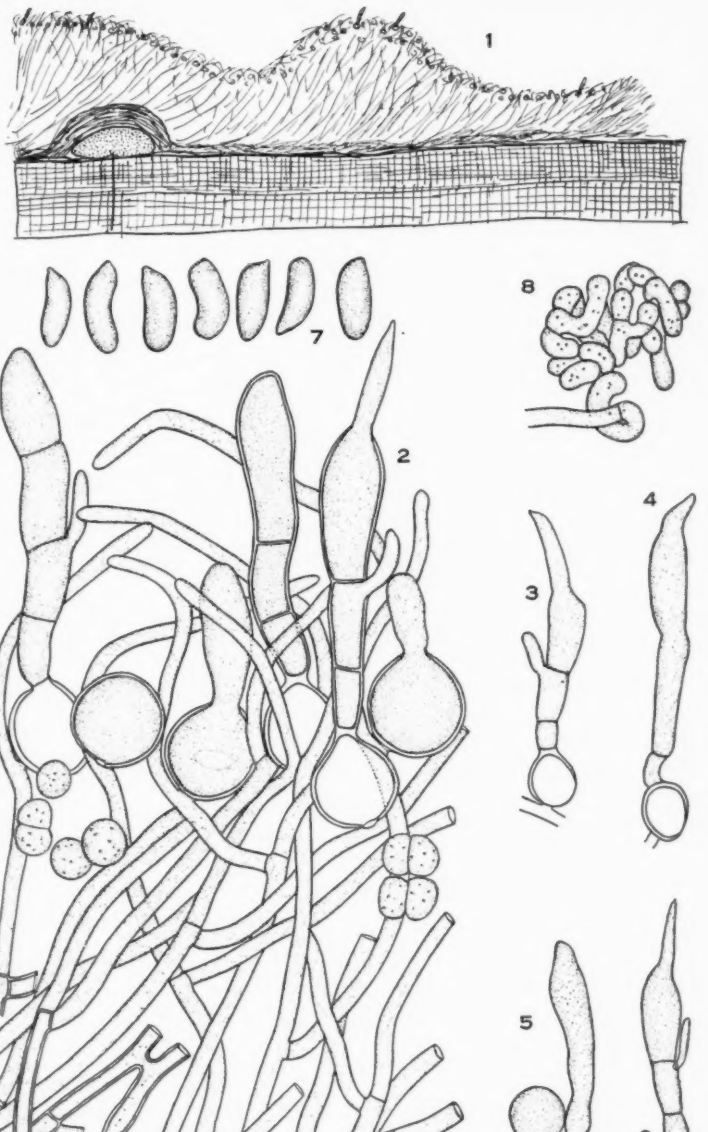


Plate 39

Figs. 1–10. *S. apiculatum* n. sp.

Fig. 1. Section of fungus showing stratified condition. No mound or apicules shown. × 33.

Fig. 2. Hymenium showing probasidia (?), basidia and spore. × 833.

Fig. 3. Spores. No. 9302. × 833.

Figs. 4–9. Probasidia and basidia. × 833.

Fig. 10. Haustoria. × 833.

Figs. 11–12. *S. Cokeri* n. sp.

Fig. 11. Probasidia and basidia, the middle probasidium showing internal proliferation. × 700.

Fig. 12. Spores. × 700.

PLATE 39

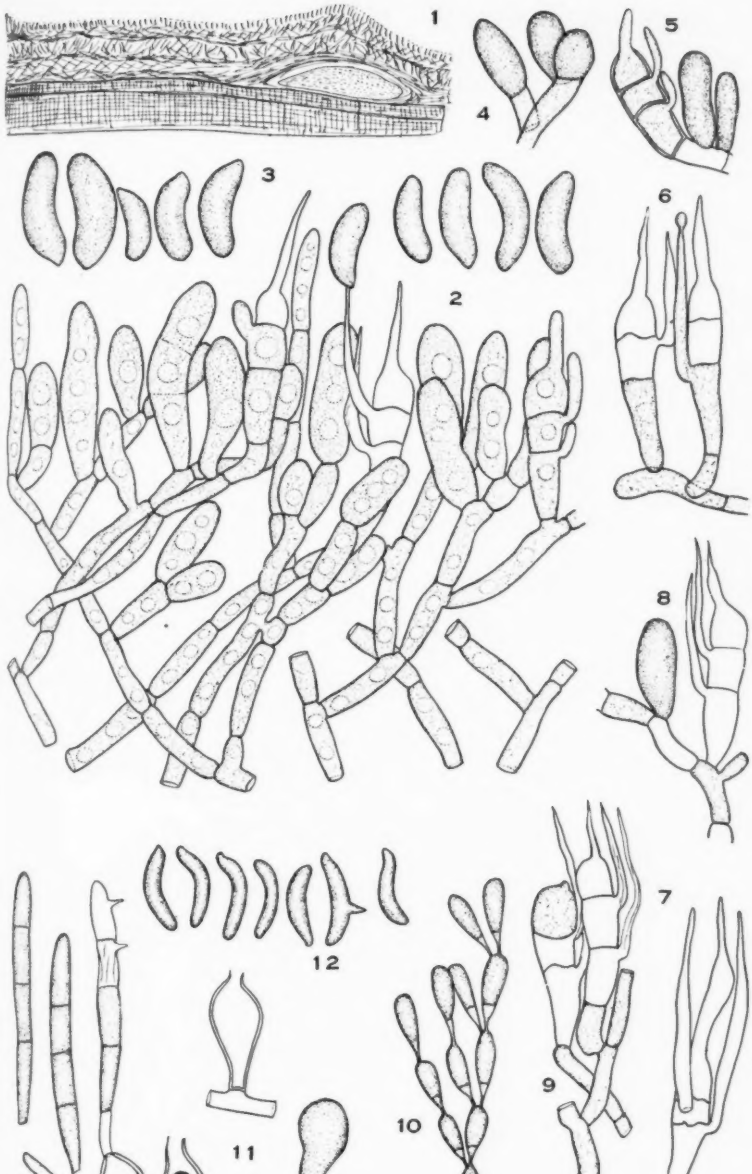


PLATE 40

S. sabalis n. sp.

Fig. 1. Section of fungus showing three horizontal layers, scale insects between subiculum and middle layer. Note basidia at surface of top layer. × 23.
Fig. 2. Hymenium showing probasidia, basidia, paraphyses, and spore. × 833.
Fig. 3. Spores. × 833.
Figs. 4–6. Basidia. × 833.
Fig. 7. Haustorium. × 833.

PLATE 40

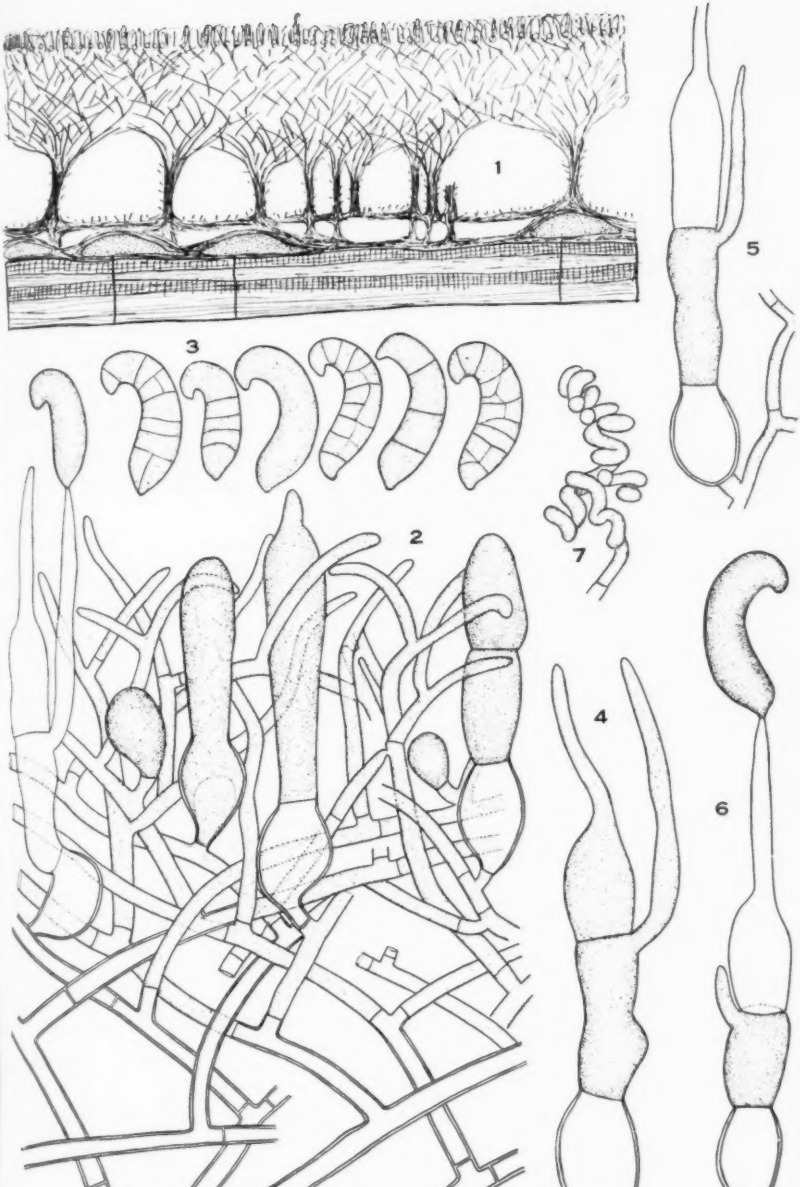


Plate 41

S. Langloisii Pat.

Fig. 1. Surface view showing marginal condition. No. 9196. × 9.
Fig. 2. Section of context showing hymenium and scale insects. × 33.
Fig. 3. Hymenium showing upright (hyaline) paraphyses, probasidia, basidia, and spores. Daytona Beach, Fla. Thaxter, coll. × 833.
Figs. 4–6. Probasidia and basidia. No. 9196. × 833.
Fig. 7. Basidium and three spores of type. No. 2995. × 833.
Fig. 8. Haustoria. No. 9196. × 833.
Fig. 9. Spores. No. 9196. × 833.

PLATE 41

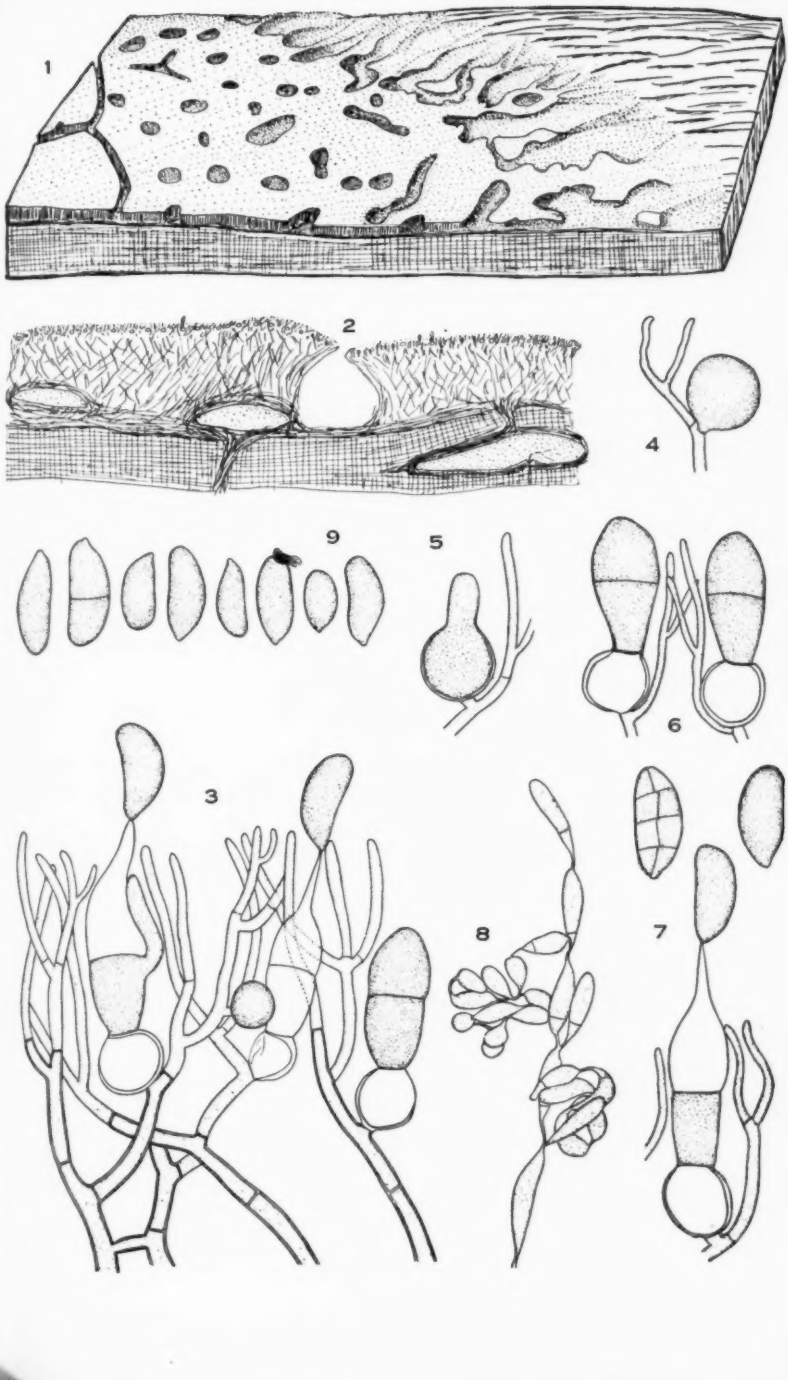


Plate 42

Figs. 1–5. *S. Patouillardii* Burt.

Fig. 1. Section of fungus in marginal region, showing top layer, pillars, subiculum, and one parasitized scale insect. × 33.

Fig. 2. Hymenium showing upright, dark colored, thick-walled paraphyses, probasidia (?), basidia, and spores. × 833.

Fig. 3. Spores. × 833.

Fig. 4. Basidium and paraphyses. × 833.

Fig. 5. Haustoria of irregular coiled type. × 833.

Figs. 6–13. *S. taxodii* n. sp.

Fig. 6. Section through fungus showing insect covered by thick upright hyphae. × 33.

Fig. 7. Paraphyses from hymenium. × 833.

Fig. 8–13. Probasidia and basidia. × 833.

PLATE 42

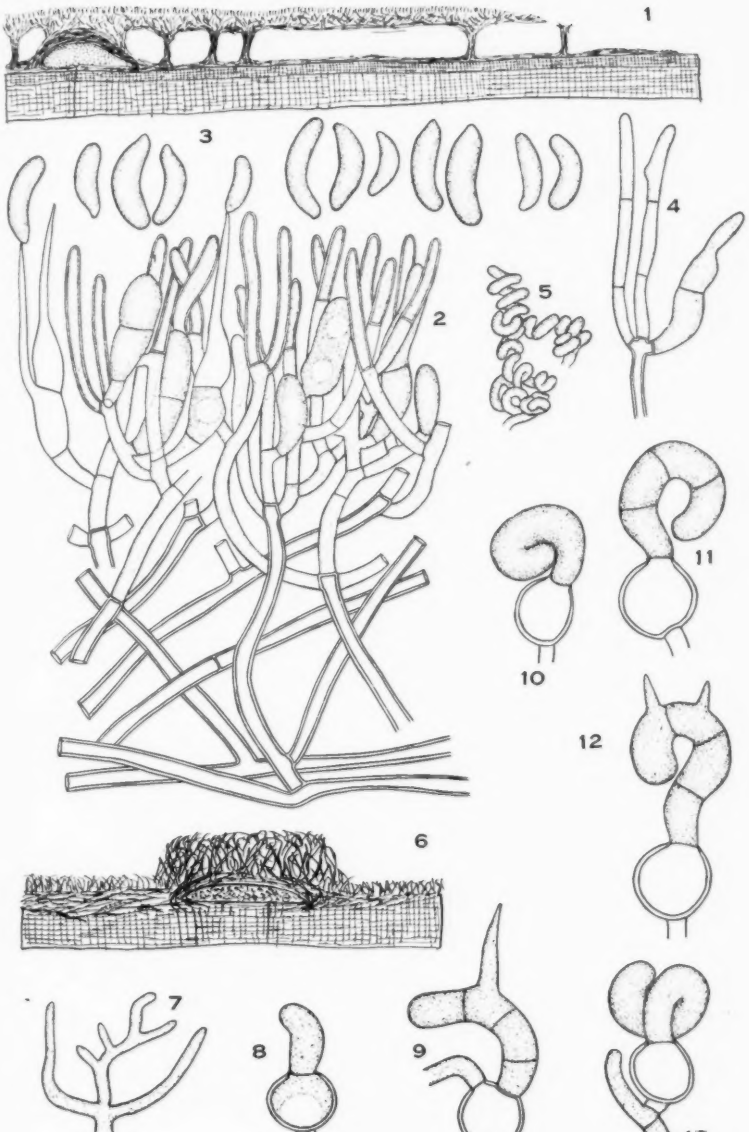


PLATE 43

S. grandisporum n. sp.

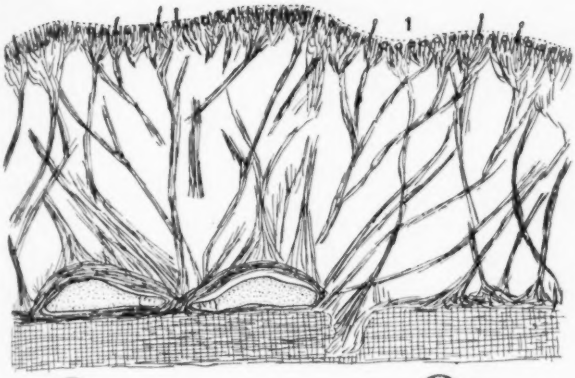
Fig. 1. Section of fungus showing hymenium, branching and anastomosing pillars, and scale insects. × 18.

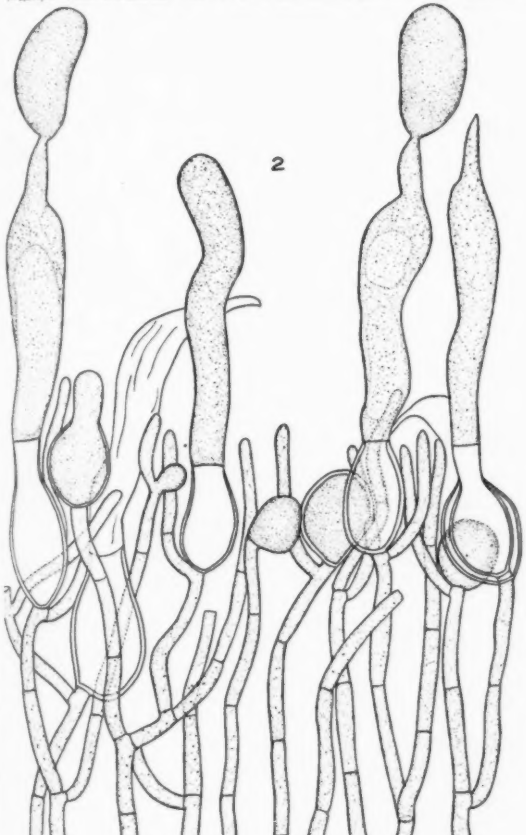
Fig. 2. Hymenium with upright paraphyses, probasidia, and basidia. × 833.

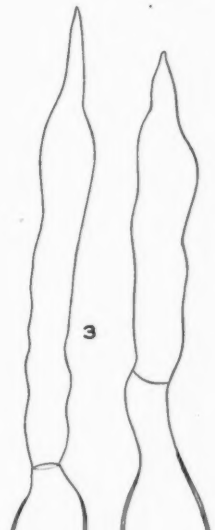
Fig. 3. Basidia. × 833.

Fig. 4. Spores, three of which have become divided into numerous small cells, the upper spore forming bud cells. × 833.

PLATE 43







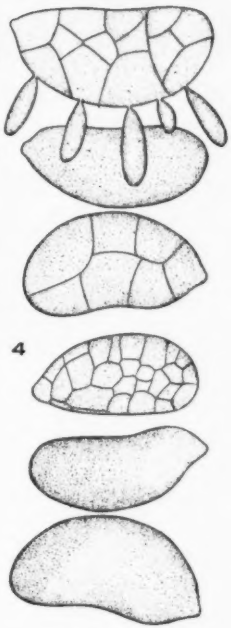
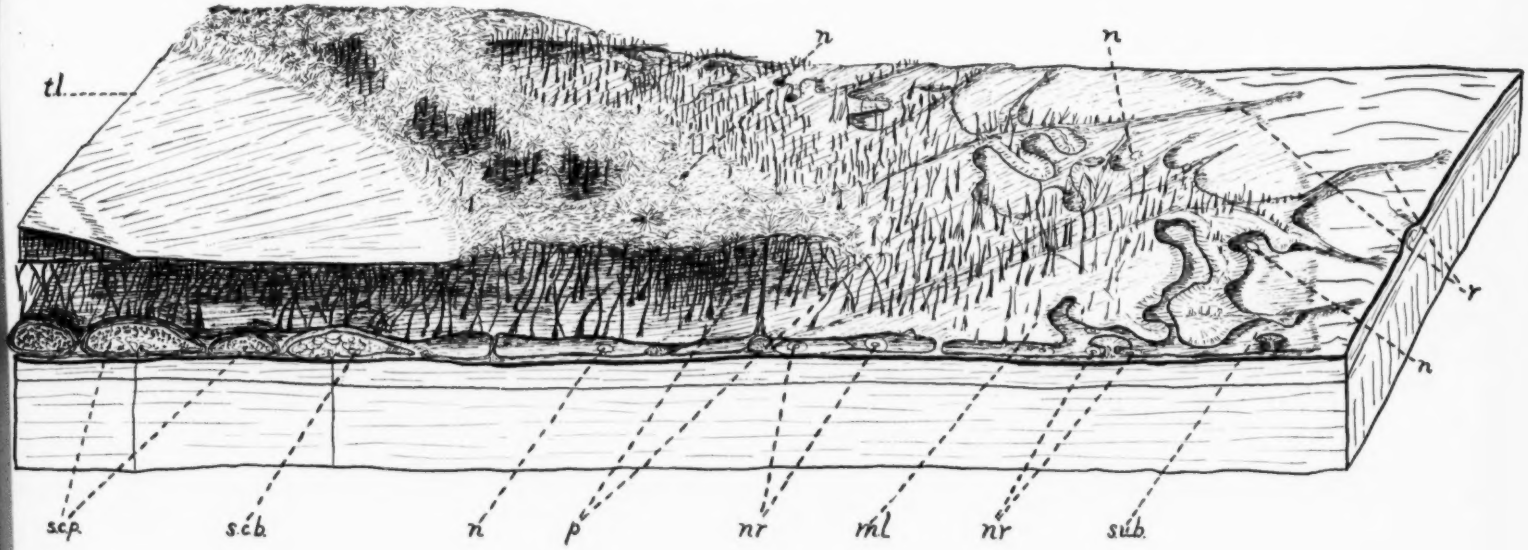


PLATE 44

S. Mariani Bres.

Sectional and surface view of fungus at time when young are being born. Note three horizontal layers (1) subiculum (sub), (2) middle layer (m.l.) and (3) the top layer (t. l.) which may sometimes be stratified. Scale insects inhabit region between middle layer and subiculum, if insects are parasitized, or between the middle region and bark, if insects are healthy. One healthy adult female (s.c.b.) is giving birth to young, several of which can be seen crawling about over the fungus (n). Some have settled down on the subiculum (n.r.). Rhizomorphs (r) are distinct, also pillars (p). Several insects are parasitized by fungus (s.c.p.). × 20.

PLATE 44



STUDIES ON VIRGINIAN TRICLADS

By Roman Kenk

Plate 45 and 21 Text Figures

There is but little information on fresh-water triclads or planarians (*Probursalia* or *Tricladida paludicola*) in Virginia available in literature. The only data I was able to find were the following: Girard (1852, p. 211) established the occurrence of *Dugesia Foremanii* (see *Curtisia foremani*) in Virginia, in the vicinity of Washington, D. C. Kepner and Rich (1918) studied the reactions of the proboscis of "*Planaria albissima*" (see *Fonticola morgani*) collected in the vicinity of the University of Virginia. Taliaferro (1920, p. 63) collected *Planaria maculata* in the same place. Kepner and Pickens (1925, p. 237) give some information on *Trichodina Steinii* found upon the surfaces of "*Planaria polychroa*" (? see *Curtisia foremani*) which had been collected also near the University of Virginia.

In view of the scantiness of our knowledge of the planarian fauna in Virginia, and the southern states generally, I gladly seized the opportunity to study the distribution of this group in Virginia, I being at the time occupied chiefly in physiological research. The account given in this paper is, of course, far from being complete. There still remains much work to be done in this direction. A great part of the country is still unexplored with regard to the occurrence of planarians (see map, Fig. 29).

In this paper I have also included observations on the morphology and ecology of the animals studied. I have tried to supplement the data given by previous authors whenever it seemed desirable. It has been repeatedly pointed out that for the experimental worker an intimate knowledge of his material, particularly an exact identification of the animals, is of great importance. From this point of view, the present contribution may be considered an attempt to secure a basis for further physiological investigations on planarians from Virginia.

Most of the work dealt with in this paper was carried out at the Miller School of Biology, University of Virginia, during the session of 1931–1932. It was continued and concluded at the Department of Zoology, University of Ljubljana, Yugoslavia. I take the opportunity to acknowledge my deep indebtedness to the Rockefeller Foundation which

enabled me to spend a year at the University of Virginia. I also wish to express my appreciation of the many privileges extended to me by Dr. William A. Kepner and Dr. Ivey F. Lewis of the Miller School of Biology. My best thanks are due to all those who assisted me in procuring material from many localities in the state or were in other ways helpful to me. I am particularly indebted to Miss Ada A. Blanco who kindly took charge of the cultures of planarians after my departure from America.

In the taxonomic arrangement of the animals I have, in the main, followed the latest revisions of fresh-water triclads (Kenk, 1930b, and Hyman, 1931b). Two species and one variety appear to be new or, at least, hitherto undescribed.

Curtisia foremani (Girard).

For earlier accounts of this species see Hyman (1931b, p. 322).

THE EXTERNAL FEATURES are already well described by former investigators. I only wish to refer to Figures 1 and 9, a photograph, and a sketch of the living animal.

REPRODUCTIVE ORGANS: I have only a few details, though important ones, to add to Curtis's (1900a) excellent description of the reproductive system. The species stands out in several peculiarities, among which the exceedingly small number of testes and the lobate shape of the ovary are the most interesting. The copulatory apparatus (Fig. 15) is strikingly small. The atrial cavity does not form definite compartments, such as are distinct in some other planarians, and therefore ought to be considered a combination of the male and common atria. The atrium is connected with the genital pore by a narrow canal. The penis consists of a feebly muscular bulb and a finger-shaped papilla or penis proper. The vasa deferentia open separately into the upper part of the penis cavity or seminal vesicle situated in the penis bulb. Posteriorly, this cavity leads into a narrow ejaculatory duct which opens at the point of the penis. More extensive data on the histology of these organs may be found in Curtis's paper. I merely illustrate their general structure, with particular regard to the musculature, in a diagrammatic figure (Fig. 15).

An important fact that has been overlooked by Curtis (1900a, p. 456) and Stevens (1904, p. 210) is the existence of a genito-intestinal communication in this species. Curtis states that the bursa copulatrix ("uterus") lacks an enlarged cavity and that it is blindly closed anteriorly.

In all of my slides I see the bursa stalk opening directly into the

intestine. The two posterior intestinal rami bear branches not only on their lateral sides, but also on the medial sides (a similar branching has also been found in several other triclads). In the postpharyngeal region these medial branches are comparatively well developed and approach the median line rather closely. At the level of the copulatory organs they usually lie dorsally to these. The bursa stalk, starting from the posterior and dorsal part of the genital atrium, first runs dorsally. The common oviduct opens from behind into a small enlargement of it ("uterus," Stevens). The walls of this widened portion are perforated by numerous outlets of eosinophilic shell glands. From here the bursa stalk continues anteriorly and more or less laterally and connects with one of the medial branches of the intestine already mentioned. This part of the bursa stalk ("uterus," Curtis) varies in length and position and usually turns towards the right, more rarely the left, side of the body to lead into a branch of the same side. Occasionally it even connects with two branches, one of the right and one of the left side. On account of the position and histological structure this duct evidently corresponds to a true bursa stalk and not to a modified bursa copulatrix ("uterus"), as Curtis assumes.

At the transitional point between the bursa stalk and the intestinal branch I did not find any particular structures. The lumen of the stalk apparently does not continue directly into the intestinal cavity, but is shut off practically by the close contact of the cells of the intestinal epithelium. Nothing in the nature of a sphincter is developed.

Recently, several authors have discussed the morphological and physiological rôle of the genito-intestinal communications found in a number of Turbellaria (see particularly Steinböck, 1924, and Reisinger, 1929, p. 61–64). Without attempting to recapitulate their assumptions and conclusions more fully I want to state that the conditions observed in *Curtisia foremani* agree perfectly with Steinböck's theories Steinböck assumes that the bursa copulatrix of the triclads originated (phylogenetically) from a portion of the intestine. Even now it shows a similar structure and, to a certain degree, performs a function similar to that of the latter.

The function of the bursa has been often and amply discussed in the literature concerned. I will merely refer to Graff's (1912–1917, p. 3101–3110) critical review of the facts observed and the hypotheses expressed by various authors on this subject. One fact appears to be well established, viz. that in many triclads the bursa receives sperm from the co-copulant during copulation. Later on the sperm, or at least a part

of them, enter the oviducts and proceed towards the ovaries. Finally they reach the widened anterior parts of the oviducts ("tubae" or seminal receptacles) where they are deposited. Often superfluous sperm are resorbed in the bursa and other parts of the genital tract (Černosvitov, 1931).

Curtisia foremani is, apparently, an exception to this general rule in planarians. In copulation the relatively small penis is inserted into the posterior part of the bursa stalk ("vagina") of the co-copulant. Its point may penetrate as far as the small widening of the stalk where the oviducts open into it. Apparently the sperm immediately enters the common oviduct which in this species is provided with a comparatively wide lumen. Superfluous sperm may be carried off by the anterior part of the bursa stalk and digested in the intestine.

These conditions, differing from those observed in other triclads, give the species a separate position among the planarians. Genito-intestinal communications have been established in other fresh-water triclads as well (in *Euplanaria absoloni*, Komárek, 1919, p. 38, and Steinböck, 1924, p. 490–492; and in several species of the family *Dendrocoelidae*, Beauchamp, 1932, pp. 140, 159, 164, 210, 254). In these instances, there is either a distinct bursa present or, more rarely, the bursa stalk connects with a transverse, postpharyngeal commissure of the intestinal rami. In the latter case (*Eupl. absoloni* and *Acromyadenium maroccanum*) the median part of the commissure generally shows a structure similar to that of the epithelium of a true bursa. It seems significant that *Curtisia foremani*, which entirely lacks a bursa copulatrix, appears in other characteristics as well to be the most primitive species among the fresh-water planarians.

ECOLOGY AND DISTRIBUTION: *Curtisia foremani* inhabits cool creeks and is usually found attached to the lower surfaces of stones. It is widely distributed in the United States.

Distribution in Virginia:

(1) Virginia, near the boundary line, in the vicinity of Washington, D. C. (Girard, 1852, p. 211: *Dugesia Foremanii*).

(2) ? Kepner and Pickens (1925, p. 237) collected "*Planaria polychroa*" in the vicinity of the University of Virginia, Albemarle County. I assume their species to be identical with *Curtisia foremani*.

(3) Tributary of the Ivy Creek, near Charlottesville, Albemarle County. Swiftly running creek with clean water; bottom stones and mud, without vegetation. January 24 (water temperature 11.7°C.) and February 20, 1932 (7.5°C.): numerous mature and immature specimens and several cocoons collected under stones.

(4) Swamp near Rio, about 3 miles from Charlottesville, Albemarle County. July 6, 1932 (coll. Mr. T. K. Ruebush).

(5) Creek crossing the highway Charlottesville—Keswick, about 5 miles from Charlottesville, Albemarle County. Swiftly running, not very clear, water; bottom muddy, with stones. March 20, 1932: one mature specimen collected under a stone.

(6) Creek crossing the highway Charlottesville—Keswick, about 7½ miles from Charlottesville, Albemarle County. Swiftly running water, bottom muddy, with stones. April 17, 1932: one mature specimen collected under a stone.

(7) Creek near Waynesboro, Augusta County. Creek crossing the highway Waynesboro—Mt. Meridian about two miles from Waynesboro, tributary of the South River. Swiftly running, not very clear water; bottom with mud and stones. March 26 and April 3, 1932: numerous immature and mature specimens collected.

(8) Jenning's Branch near Turner Ashby Farm, on the highway Staunton—Churchville, Augusta County. Swiftly running creek, water not very clear, bottom with stones. June 15, 1932 (water temperature 23.3°C.): several young and mature specimens collected under stones.

(9) Tinker Creek at Cloverdale, Botetourt County (about 7 miles northeast from Roanoke, Roanoke County). Swiftly running, not very clean water. April 22, 1932: one mature specimen collected under a stone.

(10) Outlet of the (artificial) lake at the Girl Scout Camp of Richmond, near Bon Air, Chesterfield County. July 23, 1932: several young specimens collected under stones.

(11) Creek on the road Newport—Mountain Lake, about two miles from Newport, Giles County. August 8, 1932: several immature specimens collected under stones.

(12) Small arm of Bullpasture River about 5 miles below McDowell, Highland County. June 6, 1932: several immature and mature specimens and cocoons collected under stones.

REPRODUCTION, DEVELOPMENT: In the laboratory the animals, if well fed, are easily induced to deposit egg-capsules. These are round (diameter 1.27–1.7 mm.) and provided with a thin, often filiform and curved stalk. At the end of the stalk there is a small disc consisting, apparently, of the same substance as the stalk. By this disc the stalk is attached to the substratum. The stalk is soft and does not keep the cocoon in an upright position; it merely anchors the egg capsule.

At indoor temperature the young animals hatch about 12 days after the cocoon has been laid.

Euplanaria tigrina (Girard)

Synonyms: *Planaria maculata* Leidy, 1847b.
(non *Planaria maculata* Fabricius, 1826: a rhabdocoel.)
(non *Planaria maculata* Darwin, 1844: a terricole triclad, *Geoplana maculata*.)
(non *Planaria maculata* Dalyell, 1853: a polyclad.)
Dugesia maculata Girard, 1851.
Euplanaria maculata Kenk, 1930b.
Planaria tigrina Girard, 1850.

Euplanaria tigrina was first described by Leidy (1847b) under the name *Planaria maculata*. Girard (1851) transferred the species to his new genus *Dugesia* which, however, has not been recognized by later authors. Recently, since the taxonomic position of planarians has been established according to their anatomical features, this species ranks with the genus *Euplanaria*.

So far it has been overlooked that the name *Planaria maculata* had been already used by Fabricius (1826, p. 34) and Darwin (1844, p. 246) for other species of Turbellaria, before Leidy's paper was written. The name of our animal ought, therefore, according to the International Rules of Zoological Nomenclature,[1] to be rejected as a homonym. In our case this is a very inconvenient demand, because the species belongs to the commonest of North American planarians and is one of the most popular subjects of physiological investigations. It is mentioned in an exceedingly large number of experimental papers and text-books, usually under the name of *Planaria maculata*. Nevertheless, seeing that a yet greater confusion in zoological nomenclature can be avoided only by strict observance of the International Rules, I recognize the necessity of rejecting the preoccupied name *maculata*. Dr. L. H. Hyman, in a private communication, kindly called my attention to the name *Planaria tigrina* Girard (1850, p. 264) as being the next oldest name of the species. I am, therefore, adopting *Euplanaria tigrina* (Girard) as the valid name.

Several authors have pointed out that the species does not appear uniform, or have attempted to split it up into several distinct species (Sivickis, 1923; Hyman, 1920, p. 405; 1931b, p. 324–326; 1931c). The differences between these forms concern chiefly the size and the proportions of the body, and the color and pattern of the surface. So far it is not easy—as Hyman points out—to draw a definite dividing line between these forms. Unfortunately, *Euplanaria tigrina* frequently occurs in asexual colonies, reproducing by fission. There are only certain localities where sexual animals may be found, usually during the warm season, while in other places a continuous agamic reproduction has been observed for many years (cf. Curtis and Schulze, 1924, p. 105). These facts render it difficult to compare the anatomy of the reproductive organs of animals from different geographical areas, showing slightly differing external features. Such a comparison would be of great assistance in establishing specific differences and giving exact definitions of the various taxonomic units.

Yet a very close relationship between these forms appears to be

[1] See: *X^e Congrès international de zoologie, tenu à Budapest 1927. Annexe, p. 1583–1594. Budapest, 1929.*

indubitable. Hyman (1931b) has given a review of the forms concerned: *Euplanaria maculata*, *E. novangliae* Hyman, and *E. microbursalis* Hyman and has united them in a "*Euplanaria maculata* group" with definitely marked features.

I had an opportunity to investigate sexually mature specimens belonging to this group and obtained from Chicago, Ill., Falmouth, Mass., and Richmond, Va. According to Hyman's classification these animals belong to the species *Euplanaria maculata* and *E. novangliae*. The copulatory organs, however, afforded no means of discriminating between them.

In view of this situation, it would in many cases prove impossible to establish the proper taxonomic position of preserved animals belonging to *Euplanaria tigrina* or *E. novangliae*. Sometimes only the study of living specimens would reveal the slight differences characteristic of the forms in question. We, therefore, may assume that these forms are related closely enough to be united into one species, *E. tigrina*. *Euplanaria novangliae* would consequently have to be considered a subspecies of this species. *Euplanaria microbursalis*, which I did not have for comparison, appears to be a separate species.

THE ANATOMY of *Euplanaria tigrina* has been intensively studied, particularly by Bardeen (1901) and Curtis (1902). I merely want to add a few observations which may supplement and, to a certain extent, correct the descriptions of the reproductive organs given by Curtis (1900b, 1902) and Sivickis (1923). Figure 16 represents a diagram of the copulatory apparatus, with special regard to the arrangement of the muscle fibers. The preparation from which the figure is drawn was made from a specimen from Falmouth, Massachusetts. It was collected in one of the places where Curtis obtained his material (pond south of the road, behind the Episcopal Church). Nevertheless it conforms in all essential features to animals from Richmond, Virginia, and Chicago, Illinois (kindly sent by Dr. Libbie H. Hyman). Hyman (1931b, p. 325) is inclined to consider Curtis's form *E. novangliae*.[2]

It is remarkable that in fully mature animals much of the epithelium of the copulatory organs is "depressed," viz. the nuclei of the epithelial cells are depressed into a deeper layer. This is true for the epithelium

[2] Miss L. H. Hyman, in a private communication, informs me that recently she had made many more sections of sexual specimens of different provenance and cannot find any differences whatever in the reproductive systems. She is now likewise inclined to unite the various forms into one species and even doubts if we can clearly discriminate between definite varieties in that.

lining the male and common atria, the vagina (the posterior part of the bursa stalk), and that coating the penis. Normally developed epithelium (with nuclei in the cells themselves) is found in the canal connecting the common atrium with the genital pore, in a transition area between the two compartments of the atrium, in a small area surrounding the opening of the ejaculatory duct at the point of the penis, and in the anterior part of the bursa stalk (between the bursa copulatrix and the openings of the oviducts).

The two oviducts open into the bursa stalk from the posterior and lateral side. They do not seem to unite before attaining the bursa stalk, but to open independently, though very close to each other.

The "circular groove or furrow" near the point of the penis described by Sivickis (1923, p. 116) is an inconstant feature. It appears to be brought about by the different structure of the epithelium in this place, where the lining of the ejaculatory duct encroaches on the external surface of the penis. In this area the compact muscular layer of the penis wall is lacking. This place, therefore, is mechanically less resistant and appears more or less deformed in the preparations, according to the state of muscular contraction in which the organ has been fixed.

ECOLOGY AND DISTRIBUTION: *Euplanaria tigrina* is widely distributed in the United States and is not infrequent in Virginia. Here it lives in smaller and larger pools and ponds, preferring stagnant water. It is found between water plants and on the under surfaces of stones.

Distribution in Virginia:

(1) Sinclair's Pond, Park Street, Charlottesville, Albemarle County. August 20, 1931: numerous small specimens brought into the Laboratory with samples of water plants.

(2) Pond on the highway Charlottesville—Lynchburg, near Charlottesville, Albemarle County. September 2, 1931: a few asexual specimens collected between water plants.

(3) Big Spring, near Kerr's Creek, Rockbridge County. A big pond fed by several small springs immediately on its bank. Besides this form, *Fonticola morgani* var. *polycelis*, *Planaria dactyligera* and *Procotyla typhlops* are found in this locality. *Euplanaria tigrina* occurs in the warmer parts of the pond. September 11 and October 11, 1931: numerous asexual specimens collected between water plants.

(4) Mountain Lake, Giles County. Natural lake situated at an altitude of about 4000 feet. Limnological data on this locality have been published by Hutchinson and Pickford (1932). November 23, 1931, and July 7, 1933: one asexual specimen collected under a stone near the north bank.

(5) Trice's Lake, Cumberland County. Artificial lake with shallow water, bottom (near the bank) muddy or sandy, with few stones, here and there rich vegetation. April 26, 1932: several asexual specimens collected under stones.

A few stalked cocoons, mostly empty, were also seen; they probably belonged to this species.

(6) Outlet of Westhampton Lake, University of Richmond, Henrico County. July 23, 1932: numerous specimens of various sizes, part of them mature, and several cocoons collected under stones.

REPRODUCTION: In *Euplanaria tigrina* both sexual and asexual reproduction occurs. The type of reproduction and the life cycle may vary in different localities, as has been established by Curtis (1902; Curtis and Schulze, 1924). In Virginia, I collected sexually mature animals only near Richmond; Trice's Lake likewise seems to contain a sexual form of this species during the warm season. From the other localities listed I obtained specimens reproducing by fission. I kept cultures of them for many months without observing any traces of copulatory organs.

Sexually mature lots deposited egg capsules in aquaria. They are spherical and attached to the substratum by a stalk.

Fuller information on the ecology and development of the animals as well as on the keeping of them in laboratories may be found in the papers quoted and in many experimental papers dealing with this species.

Euplanaria dorotocephala (Woodworth)

In her revision of the North American fresh-water triclads Hyman (1931b, p. 323) establishes a "*Euplanaria dorotocephala* group" which embraces several species closely related to each other, viz., *Euplanaria dorotocephala*, *E. agilis* (Stringer), and *E. philadelphica* Hyman. They differ from each other by the color and pattern, to some degree also by certain anatomical features.

In several localities in Virginia I have collected planarians which belong to this group. Unfortunately, I was not able to induce the development of sex organs in all these lots. The external features of specimens from different lots were slightly different, particularly the details in the arrangement of the body pigment. It is well known that the color of *Euplanaria dorotocephala* is more or less subject to change and is even influenced by the temperature of the water. Therefore, the color of animals kept at indoor temperature for some time cannot always be considered normal (Hyman, 1929, p. 407).

Sexually mature specimens, which I obtained from two cultures, conformed entirely to the general anatomical plan characteristic for the group. Slight differences between individual specimens were presumably due to different stages of maturity or different states of contraction

in the fixing fluid. In general, the animals resembled *E. dorotocephala* rather than *E. agilis*. I may, therefore, assume that my material belonged to that species, which is widely distributed in the central and eastern states.

The relationship between the forms of the *E. dorotocephala* group appears to be similar to that between the representatives of the *E. tigrina* group discussed in the previous chapter. In view of the slightness of the anatomical differences between the various forms it seems advisable to unite them all in one single species, viz. *E. dorotocephala*. The separate forms might be considered subspecies or varieties of this species rather than separate species.

ECOLOGY AND DISTRIBUTION: In Virginia *E. dorotocephala* occurs in cool creeks with clean water. It can be collected on the under surfaces of stones. I have never found mature specimens in the field.

Distribution in Virginia:

(1) Big Spring, near Kerr's Creek, Rockbridge County. October 11, 1931: numerous specimens collected in the outlet of the big pond (water temperature 19°C.).

(2) Creek near Waynesboro, Augusta County (the same locality as that where *Curtisia foremani* was collected). March 3, 1932: one specimen under a stone.

(3) Spring at Turner Ashby Farm, close to Jenning's Branch, on the highway Staunton—Churchville, Augusta County. Clean, cold spring, outlet with stones. June 15, 1932 (water temperature 16.1°C.): several specimens.

REPRODUCTION, DEVELOPMENT: Both in the field and in the laboratory, *E. dorotocephala* mostly propagates asexually. In the laboratory, at indoor temperature as well as in an ice-box (temperature 10–12°C.) several cultures attained sexual maturity. Specimens from Big Spring laid many cocoons, all of them sterile, however. The cocoon is spherical, with a diameter of about 1½ mm., and provided with a stalk which ends in a disc attached to the substratum (Fig. 20). The stalk is usually somewhat curved, of various lengths (in an extreme case it attained 5 mm.). Freshly deposited egg capsules are milky white; after a few hours they become yellowish, gradually turn reddish brown, and finally, after some days, almost black.

Fonticola gracilis (Haldeman), n. comb.

Synonyms: *Planaria gracilis* Haldeman, 1840.
Phagocata gracilis Leidy, 1847a.
Euplanaria gracilis Kenk, 1930b.

The structure of this species has already been intensively investigated by Woodworth (1891) and Peaslee (1910). In these papers, the older

publications on *Fonticola gracilis* are quoted and summarized. Nevertheless, the anatomical descriptions are not complete and, partially, incorrect.

THE EXTERNAL FEATURES of the animal are already well known. I refer to Figures 4 and 10, the first being a photograph of the gliding animal, the latter illustrating the outline of it.

REPRODUCTIVE SYSTEM: The structure of the copulatory apparatus is of great importance to the taxonomist and a great help in the exact identification of planarians. I shall, therefore, give a more complete description of it even at the risk of some repetition.

The genital pore (see Fig. 17) leads into a small cavity into which opens the stalk of the bursa copulatrix; I call it, therefore, the common atrium. Anteriorly a tubiform portion of the atrium proceeds from this cavity, sometimes forms a sigmoid loop and widens into a rather voluminous cavity containing the penis; this cavity is the male atrium.

The epithelium of the anterior part of the male atrium is extremely flattened, but caudally it gradually becomes cubical; a similar cubical epithelium lines the common atrium. Two layers of muscles surround the atrium, a circular and a longitudinal one. Beneath the flattened epithelium of the male atrium the musculature is but little developed and apparently consists only of longitudinal fibers. Posteriorly a circular layer is wedged between this and the epithelium. Both layers are particularly strong in the tubiform posterior portion of the male atrium (Peaslee calls this portion the "muscular tube").

The penis ("sperm receptacle," Peaslee) is a comparatively large and highly complicated organ. It is composed of a relatively small bulb embedded in the parenchyma, and a large papilla, or penis proper, projecting into the male atrium. Both portions are highly muscular. The penis is cone-shaped in the basal part, posteriorly it becomes tubiform, gradually tapering towards the point. This tubiform portion may have a different position in the slides. It is always bent and sometimes even forms several loops, lying either in the enlarged part of the male atrium or protruding into the tubiform section of it. Peaslee, in his Figure 33, draws a part of the papilla telescoped, as it were. I never saw a similar phenomenon in my preparations; apparently it is due to an abnormal retraction of the organ, when the animal was being killed.

The vasa deferentia, after forming a loop on each side of the atrium, enter the penis bulb laterally and ventrally, as Peaslee correctly states. In the penis they run first dorsally, then turn towards the penis proper and gradually converge. They unite, without enlarging, to form a short common vas deferens which proceeds along the main axis of the

penis and opens into a small cavity. This does not exhibit any special glandular differentiation, the lining epithelium resembling the wall of the vasa deferentia. The cavity empties into another, larger one, of different histological structure: the seminal vesicle. The lumen is closely packed with lumps and granules of secretion of faintly eosinophilic nature. This secretion apparently originates in the degeneration of tall columnar or club-shaped cells of the epithelium; between these masses of secretion, remains of disintegrating cells and even nuclei may be observed. This cavity presumably corresponds to the structure called "anterior seminal chamber" by Peaslee.

The outlet of the seminal vesicle is a canal which proceeds through the tubiform section of the penis and opens at its point. The lumen is, in general, relatively narrow, of unequal diameter, i.e. it may be wider or narrower locally. Nevertheless, a constant "posterior seminal chamber," such as Peaslee describes and illustrates, does not exist.

Peaslee states that near the point of transition from the conical, basal, to the tubiform, distal, part the penis is connected "by a ligament-like structure with the walls of the main sheath"—the male atrium—"surrounding the sperm receptacle"—penis. I have not seen any trace of such a structure nor has a similar connection been as yet observed in any other planarian. The observation is apparently erroneous and perhaps due to the fact that, in his preparations, glandular secretion present in the atrium bridged the space between the penis and the wall of the atrium.

The histological structure of the penis is rather complicated: The penis bulb consists of a very dense network of muscle fibers arranged in flattened bundles and forming vaulted layers. The penis proper is coated with an extremely flattened epithelium with sparse nuclei which project a little beyond the general surface. Under the epithelium is a relatively thick layer of fibrous structure (see Fig. 17, *fl*), usually stained faintly pink in the preparations and therefore well marked off from the muscular fibers. In tangential sections two systems of fibers may be observed in this layer, running parallel to the surface of the organ and obliquely to its main axis, crossing each other diagonally. Several strata of such fibers alternate in the fibrous layer. They most likely represent the structure described by Woodworth as "alternating layers of circular and longitudinal muscles, five of each, forming a thick zone" (1891, p. 32). They do not, however,—as already mentioned—react towards histological stains like muscle fibers and also are much thinner than these. Presumably they belong to the same category of tissues

as similar fibrous structures occurring in a similar position in *Dendrocoelopsis spinosipenis* (Kenk, 1925, p. 141). Their function seems to be mechanical, though entirely passive, giving a certain resistance and elasticity to the wall of the penis and serving as a base for the attachment of muscles.

Under the fibrous layer, the network of muscles in the penis bulb continues into the penis proper up to the level of the seminal vesicle. In the narrow, distal, part it is, however, substituted for by (chiefly) longitudinal muscles which are extended in the space between the fibrous layer and the epithelium of the ejaculatory duct.

The bursa copulatrix is a relatively large, more or less lobate, sac lying close to the pharyngeal chamber. Often the latter even extends backwards on both sides of the bursa and in the space between this and the ventral body wall (Fig. 17). The bursa stalk ("vagina," Woodworth; "uterine duct," Peaslee) runs on the right side of the penis in all my preparations, while Woodworth and Peaslee indicate that it runs on the left side. The stalk becomes wider posteriorly. It is formed by an epithelial lining coated with two layers of muscle fibers, a circular and a longitudinal one. The wide posterior part of the stalk, which exhibits a stronger musculature, may be distinguished from the anterior portion as a "vagina."

The two oviducts run posteriorly above the ventral nerve cords. At the level of the copulatory organs they turn medially, the left one passing under the bursa stalk. They unite above the posterior part of the tubiform section of the male atrium and by means of a short common oviduct open into this. Peaslee's Figures 32 and 33 show the oviducts embracing the bursa stalk. This does not occur. Woodworth's indication that the oviducts empty into the bursa stalk is likewise incorrect.—Numerous shell glands open into both oviducts in their sections between the point where they leave the nerve cords and the point of fusion, as well as into the upper part of the common oviduct.

ECOLOGY AND DISTRIBUTION: *Fonticola gracilis* has been found in several springs and spring-fed ponds in Virginia. It is, however, well known that the species occurs frequently in stagnant water as well. It may be collected on the lower surfaces of stones, between dead leaves lying in the water, and on water plants.

Distribution in Virginia:

(1) Spring near the railroad depot at East Radford, Montgomery County. The spring is cased and covered and has clean water. Outlet with muddy bottom. December 6, 1931 (water temperature 10°C.): numerous, mostly mature, specimens collected on dead leaves and stones.

(2) Spring near Endless Caverns, Rockingham County. Limestone spring on Endless Caverns Farm, 2 miles south from New Market. Clean, almost stagnant water with rich vegetation; bottom with stones. June 24, 1932: very numerous, mature and immature, specimens collected under stones.

(3) Lacey Spring, Rockingham County. Large limestone spring, artificially altered; bottom muddy with few stones, at the edge a rich vegetation of water-mosses. June 24, 1932: numerous, mostly immature, specimens brought into the laboratory with water plants.

TAXONOMIC POSITION: Since Leidy (1847a) created a separate genus, *Phagocata*, for this species, it has usually been called *Phagocata gracilis* in literature. The genus *Phagocata* was based chiefly on the presence of many pharynges in the animal. Later on, when several European polypharyngeal species were described, this feature lost its significance. On account of the description of the reproductive organs given by Woodworth (1891) the species was recently included with the genus *Euplanaria* (Kenk, 1930b). Woodworth (p. 35) states that "the oviducts open into the vagina just above the point where it enters the genital atrium" and in his Figure 42 shows them entering the bursa stalk separately. As has been shown in a previous chapter, they first unite, and then by a short common oviduct empty into the atrium. Because of this characteristic the species ought to be classed with the genus *Fonticola*. It differs, however, from most of the other species of this genus by a number of anatomical features, especially by the complicated structure of the penis. Should the genus *Fonticola* eventually be divided into several taxonomic groups, *F. gracilis* would require a group to itself and Leidy's name, *Phagocata*, would have to be restored with a new definition.

Fonticola morgani (Stevens and Boring) n. comb.

Synonyms: *Planaria truncata* Leidy, 1851.
(non *Planaria truncata* Abildgaard, 1789: a rhabdocoel.)
Dendrocoelum truncatum Girard, 1894.
Planaria morgani Stevens and Boring, 1906.
Fonticola truncata Hyman, 1931b.

Leidy (1851) was the first to describe the external features of this species, giving it the name of *Planaria truncata*. Then the species was lost sight of for more than half a century, until, in 1906, Stevens and Boring published a short description of what they believed to be a new species, *Planaria morgani*. Stringer (1918, p. 358) established the identity of the forms described in both papers and restored the older name given by Leidy. The name *Planaria truncata*, however, had

already been used by Abildgaard (1789, p. 43) to designate a rhabdocoel, *Castrella truncata*. Therefore, this name is to be rejected as a homonym and the newer name *morgani* again becomes valid.

Fonticola morgani is widely distributed in Virginia and ranks among the commonest planarians of this state. The species presents a considerable variability in the external appearance as well as in the anatomy. At first, when I had studied animals from a few localities only, it seemed to me that one ought to distinguish at least two different forms. Subsequently, I had the opportunity to investigate specimens from 18 different localities in serial sections and to compare them with material from Cold Spring Harbor, New York, kindly sent me by Dr. William A. Castle. It then appeared that the differences existing between the extreme forms are bridged over by gradual transitions in the characteristics. I shall have to return to this question later on, in the review of the anatomical structure.

There is, therefore, no reason to call these diverging forms different species; it would be very difficult to discriminate between them with a reasonable degree of certainty. Animals collected in the same locality, however, exhibit a considerable uniformity. It seems very probable that the species *F. morgani* is in process of splitting up into several species. One could talk of a "*Fonticola morgani* group" in a similar way as Hyman (1931b, p. 323 and 324) establishes a *Euplanaria maculata* group and a *E. dorotocephala* group. We also find analogous conditions in other species of the genus *Fonticola*, viz., *F. vitta* and *F. albissima* (see Beauchamp, 1932). Unfortunately, the variability of specific characteristics in the fresh-water triclads has been but little investigated.

In cases like this, the taxonomic units of secondary significance hardly should be given the rank of distinct species. The differences between the animals are often so subtle that only an extensive comparison can lead to a correct interpretation of their taxonomic position. A sure identification is rendered very difficult, particularly in animals so plastic and changeable in shape as planarians are. It is preferable by far to call them subspecies or varieties of the same species. Thus not only their presumable relation to each other would be clearly indicated, but also much confusion would be saved, which is otherwise liable to arise from the use of the wrong specific name by workers who are not particularly familiar with the taxonomy of the group.

EXTERNAL FEATURES (Figs. 6 and 11): The length of sexually mature specimens ranges from about 10 to 17 mm., the greatest width from 1.3 to 2.3 mm., the average being 14 and 2 mm., respectively. Specimens

from different localities may present certain constant differences in the dimensions of the body, which remain even after they have been kept in the laboratory for several months under the same external conditions.

The body is unpigmented and appears white when the intestine is empty. After feeding, the contents of the intestine show through; freshly collected specimens usually show a brownish, or grayish, or reddish, more rarely a greenish intestine. All regions which are free from intestinal branches, are always white—the anterior and marginal parts, the regions of the pharynx and of the copulatory apparatus.

The anterior end is truncated. The frontal profile is almost straight or slightly concave or convex, altering rapidly in outline when the animal performs groping movements. Laterally the front margin forms indistinct and rounded auricular appendages; these are kept somewhat raised during locomotion. Behind them, a very slight and insignificant narrowing of the lateral margins ("neck") may be discerned when the animal is moving. Then the margins diverge gradually to attain the greatest width at the level of the pharynx; then they converge again and meet at the more or less pointed posterior end.

In fully grown specimens the anterior end of the pharynx is situated at about the middle of the body length or a little more anteriorly. The length of the pharynx is from one-sixth to one-fifth of the entire body length. The copulatory apparatus occupies about the anterior half of the postpharyngeal region.

Usually two small eyes are present. In mature animals their distance from each other is from one-fourth to one-third of the body width at the eye level, in young animals even less (one-fifth). The distance from the front margin is smaller than the body width in big animals, while in young specimens it may be greater than the latter. Supernumerary, "secondary," eyes may occur, usually only one on one side. Specimens from certain localities, however, show an exceedingly enlarged number of eyes. I have separated these forms from the type of the species and shall describe them as a variety, var. *polycelis* (see p. 103).

THE SURFACE EPITHELIUM is constructed on the usual plan. Submarginally, a continuous zone of openings of heavily eosinophilic glands ("adhesive zone") encircles the entire body. The gland cells proper are situated in the deeper layers of the parenchyma, while the outlets perforate a strip of modified cells in the surface epithelium. These cells, or at least most of them, show the nuclei depressed into the underlying parenchyma. They also contain only few rhabdites.

On the ventral side of the head, behind the adhesive zone, a narrow

(only a few μ broad) strip of depressed epithelium follows the median line for a short distance (about 170μ). The cells here lack rhabdites and are apparently perforated by the ducts of feebly cyanophilic glands. I have not succeeded in establishing the function of this organ (a primitive adhesive organ?).

DIGESTIVE SYSTEM: The comparatively large pharynx or proboscis shows the structure distinctive for the family *Planariidae*: its inner muscular zone consists of two separate layers of muscular fibers, a circular (immediately under the inner epithelium) and a longitudinal one. The external muscular zone is also formed by a longitudinal and a circular layer, while a second (internal) longitudinal layer, such as is developed in certain planarians, is absent.

The three intestinal rami are provided with numerous lateral branches which, in their turn, are secondarily ramified. The two posterior rami are mostly entirely separated from each other; in rare cases they are connected by anastomoses. They bear short branches also on their medial sides. The number of the intestinal branches varies to a considerable extent and increases with the increasing size of the animal. Sexually mature specimens have from 7 to 13 branches on each side of the anterior ramus and from 15 to 27 branches on the lateral side of each posterior ramus. On account of the profusely branched intestine it is sometimes difficult to investigate the ramification in living animals. Perhaps the numbers given do not represent the maximum. The formula of the intestinal ramification, as it is usually written by German authors, is as follows: 15–27, 2(7–13), 15–27.

SENSE ORGANS: Besides the eyes there are auricular sense organs present. These cannot be recognized in living specimens; they are, however, distinctly discernible in the slides. They form a pair of marginal strips of "depressed" epithelium, without rhabdites, situated on either side of the head. It is not easy to establish the exact position from the cut sections, as the anterior end is more or less deformed in fixing; but presumably they occupy parts of the front margin and of the margin of the auricular appendages. The middle part of the front margin, to the length of about $\frac{1}{3}$ mm., is free from these organs. The medial ends are narrow and placed exactly at the edge of the margin; laterally the organs widen and to a certain extent pass over to the dorsal surface. Between these strips and the submarginal adhesive zone there intervenes a band of normal, rhabdite-bearing epithelium, similarly widening towards the lateral region.

REPRODUCTIVE SYSTEM: The testes are numerous, of various size,

round or polyhedral. Most of them are situated near the ventral body wall, rarely do they approach the dorsal surface by penetrating the parenchyma between the intestinal branches. It seems, however, that the latter position is caused only by lack of space. On each side of the body they form a longitudinal zone, the median area being free from them. Each zone of testes begins anteriorly at about the level of the ovaries (occasionally even in front of them) and extends posteriorly to the level of the mouth. Laterally they reach to about the place above the ventral nerve cords. In transverse sections one to five testes may be found on each side of the intestine in fully mature specimens (Fig. 24).

From the testes start fine vasa efferentia, thin-walled tubes which may be observed only in very good sections. They lead into a narrow longitudinal canal, the vas deferens, that proceeds in a more or less curved course along the medial side of each ventral nerve cord, somewhat higher than the muscular layers of the body wall (Fig. 24). Posteriorly each vas deferens widens to form enlarged and coiled tubes, the false seminal vesicles; these attain a more dorsal and medial position than the thin anterior parts of the vasa deferentia. They are easily found in the preparations, being filled with sperm. Towards the copulatory organ they narrow gradually and enter the penis bulb on its lateral sides.

A pair of ovaries or germaries is situated on the inner sides of the nerve cords at a short distance behind the cerebral commissure. Their structure conforms to the usual plan. Laterally and dorsally to each ovary, sometimes penetrating far towards the dorsal surface, lobate or funiliform masses of cells are situated; these may be compared to the "parovaria" of certain planarians. They consist of large rounded cells with round, darkly staining nuclei of granulated structure, resembling young undifferentiated yolk cells. Occasionally one may find shell-droplets in their protoplasm, such as are normally seen only in yolk cells.

The oviducts spring from the dorsal surfaces of the ovaries. They start as somewhat enlarged funnels ("tubae") which contain sperm (seminal receptacles). Soon they become narrow ducts, running posteriorly near the dorso-lateral side of each nerve cord, but not always closely adjacent to it (Fig. 24). In their main portion they are connected with vitellaria or yolk glands. The latter are distributed generally over the parenchyma, occupying chiefly the lateral and dorsal regions of the body (laterally to the nerve cords and dorsally to the intestine), but also the medial region behind the copulatory organs.

At the level of the genital atrium the oviducts turn inwards and slightly posteriorly, and unite behind the atrium, one of them passing below the stalk of the bursa copulatrix. The common oviduct thus formed runs ventrally and opens into the posterior part of the male atrium at the point where it passes over into the canal leading to the genital pore. Heavily stained eosinophilic glands empty into the dorsal two-thirds of the common oviduct and into short adjacent parts of the separate oviducts. The glands themselves lie in the surrounding parenchyma, chiefly above and behind the copulatory apparatus.

The genital atrium (Figs. 21 and 22) is relatively small and consists almost exclusively of a male atrium. A well-defined common atrium is absent and the stalk of the bursa branches off from the atrial complex very close to the genital pore. The male atrium is almost entirely occupied by the penis and repeats the shape of it. Posteriorly it tapers and connects with the genital pore through a short narrow passage, which receives the common oviduct as well. The atrium is lined by a cubical or flattened epithelium. Under this a layer of circular, and another one of longitudinal muscle fibers, are present.

The penis (Figs. 21–23) is composed of a relatively small bulb with feeble musculature and of the papilla or penis itself protruding into the atrium. The bulb is marked off from the surrounding parenchyma by a somewhat denser texture of muscle fibers, its internal portion consisting chiefly of parenchymatic tissue.

In the preparations the penis itself appears to be rather variable in shape and size. This is partially due to the different degree of maturity in the animals, partially to the different state of contraction in the fixing fluid; besides this, certain constant differences seem to exist between specimens from different localities. In general the penis is either cone-shaped or hemi-spherically rounded, sometimes gland-shaped with a constriction at the base, or it may show transitional forms. The base of the penis is coated with a ring of thickened epithelium consisting of long columnar cells of varying height, from 25 to 140μ. These cells often protrude into the atrial cavity as villus-like projections. A strong sphincter is present under the epithelium; this, by its contraction, causes the gland-like constriction of the base. The remaining part of the papilla has a cubical or flattened epithelium and a weaker layer of circular muscle fibers. Further inside, longitudinal muscles are present in both the proximal and distal parts of the penis papilla. Near the point of the papilla a peculiar muscular differentiation is developed, generally showing a wart-like appearance, more rarely a finger-like shape; it may

be more or less marked off from the rest of the papilla. It may be situated exactly at the point of the penis (Fig. 21), or lie excentrically, usually more towards the right side. It is covered by an exceedingly thin epithelium and contains a powerful musculature composed chiefly of longitudinal and dorso-ventral fibers.

Numerous outlets of glands open on the surface of the penis. The glands proper are situated far away in the general parenchyma surrounding the penis bulb, particularly to its anterior and lateral sides. The outlets penetrate the bulb and penis and empty through the epithelium. Only the thick ring of cells at the base of the penis, the muscular wart near the end, and a narrow strip of epithelium running from the wart to the base are free from gland openings. The secretion is granular and appears in a red to lilac shade after staining with hematoxylin and erythrosin.

The tubular ejaculatory duct passes through the bulb and the papilla; it is an almost cylindrical canal, slightly tapering posteriorly and often curved in winding loops. On its anterior end the two vasa deferentia open into it independently of each other. Sometimes two insignificant enlargements of the ejaculatory duct are developed to receive them. The duct opens posteriorly on the ventral surface of the penis, often rather close to its base. The lining epithelium is flattened and is coated by a distinct layer of circular muscles. The duct also seems to receive a granular secretion of pink color. No distinct seminal vesicle is present.

The bursa copulatrix is a rounded or more or less compressed, often lobate sac of varying size, according to the state of maturity of the animal. Its outlet, the stalk, proceeds to one side of the median line, usually to the left side, but occasionally to the right. Its epithelium is columnar to cubical and surrounded by a well-developed coat of muscle fibers arranged in two layers, an inner circular and an outer longitudinal one. The stalk may be differentiated into two portions, a wider and more muscular posterior one, which opens close to the genital pore, and a narrower anterior portion connected with the bursa and provided with a thinner muscular coat. The boundary between these two portions is fairly distinct in several cases (Fig. 21), so one is tempted to call the posterior part a "vagina," as we do similar structures in other planarians. On the other hand, there may be merely a gradual tapering towards the bursa without any abrupt change in the thickness of the wall (Fig. 22). Also intermediate conditions between the two extremes occur rather frequently. Specimens from the same locality generally show a uniform structure of the bursa stalk.

No adenodactyl is present.

In view of the wide variability in the copulatory apparatus, it appears to be possible to distinguish at least two different forms, which may represent two taxonomical units. However, the existence of specimens showing transitional characteristics seems to contradict this assumption. Specimens from the vicinity of Mountain Lake and from Camp Kewanzee agree in a number of features: the glands of the penis are exceedingly well developed, the muscular wart situated excentrically towards the right side of the penis, the ejaculatory duct opens farther distally, the stalk of the bursa lacks differentiation into two distinct regions. Since these specimens live in localities at high altitudes (about 4000 feet), they might be considered ecological varieties. Their peculiarities, however, remain constant even if they are kept under laboratory conditions for a long time. Nevertheless, for the reasons mentioned, I refrain from designating them as a distinct variety or subspecies.

ECOLOGY AND DISTRIBUTION: *Fonticola morgani* lives preferably in running water, particularly in places where the temperature is not very high during the summer. It occurs on the lower surfaces of stones in creeks and springs, rarer in spring-fed ponds. It may also be found in small, and even very small, springs that dry up periodically; from this fact we may conclude that it may also live in subterranean habitats, in the ground water, as is very probable in the case of several European spring planarians.

Distribution in Virginia:

(1) "Dog Spring," about 2½ miles southwest from the University of Virginia, Albemarle County. Small creek on David Fowler's Farm, by the old Lynchburg Road. Bottom muddy with little vegetation. September 8, 1931 (water temperature 17°C.): several small immature specimens found in samples of mud and water plants brought to the laboratory. The white triclads used by Kepner and Rich (1915 and 1918) for experimental purposes and in their papers called *"Planaria albissima,"* had been collected in the same place. Beauchamp (1932, p. 273) appears to assume Kepner's form to be identical with *Fonticola velata* (Stringer); this is obviously a slip, since *velata* is a pigmented species.

(2) Tributary of Ivy Creek, near Charlottesville, Albemarle County. Creek crossed on Garth Road about one-half mile beyond entrance to Farmington Country Club. Swiftly running, clean water; bottom covered with pebbles, muddy here and there, without vegetation. January 1 (water temperature 11.7°C.) and January 31, 1932 (5.3°C.): numerous immature animals collected.

(3) Chamberlain's Pond, near Charlottesville, Albemarle County. Spring-fed pond on Midmont Estate, about one-half mile from the University of Virginia. Bottom muddy, covered with many dead leaves. April 6, 1932: several immature specimens brought to the laboratory in samples of mud and leaves.

(4) Creek near Stony Point, about 6 miles from Charlottesville, Albemarle County. Small creek, swiftly running; bottom mud and stones. May 8, 1932: several immature animals collected under stones (coll. Miss Ada A. Blanco).

(5) Creek near Greenwood, Albemarle County. Creek "Stony Run" at the place called Woodland, about one-half mile from Greenwood Station. May 15, 1932: numerous specimens, some of them mature, collected under stones.

(6) Lickinghole Creek, near Crozet, Albemarle County. May 15, 1932: mature and immature specimens.

(7) Spring at Afton Mountain, Nelson County. Small spring on the right side of the highway Afton—Waynesboro, about one mile before the crest of the saddle. During the summer the spring dries up. August 31, 1931 (water temperature 16°C.) and May 1, 1932: several small and immature specimens.

(8) Creek near Waynesboro, Augusta County. Creek on the western slope of the Afton Mountain, on the left side of the highway Afton—Waynesboro, flows into the South River at Waynesboro. Clear, swiftly running water, bottom with mud and stones. May 29, 1932 (water temperature 15.1°C.): numerous specimens, among them several mature ones, collected under stones. Some animals appear to have undergone fission: short postpharyngeal regions, regenerating tail-ends.

(9) Whiskey Creek, near Churchville, Augusta County. Swiftly running water. June 15, 1932 (water temperature 20.9°C.): several immature specimens under stones.

(10) Buffalo Branch near Buffalo Gap, Augusta County. Small, sluggish stream; bottom with stones, without vegetation. June 21, 1932 (water temperature 21.1°C.): a few immature specimens collected.

(11) Springs near Mountain Lake, Giles County. (a) Small spring on the east side of the lake; it is cased and feeds the water supply of Hotel Mountain Lake. The overflow of the reservoir is an iron pipe, from which the water falls into a small pond with a sandy bottom and many decayed leaves in it. In this pond the animals were very numerous (November, 1931), particularly attached to the leaves, but also gliding freely over the bottom. The crowding of the animals appeared to be due to their positive rheotaxis: the animals, moving against the current, were forced to stay in the pond and so collected there in great numbers. September 2, 1931 (coll. Mrs. Jeanette S. Carter), November 23, 1931, June 26, and July 5, 1933: Numerous specimens, some of them mature. (b) Creeks and springs on the way from Mountain Lake to the Cascades: "Skunk Cabin Spring", "Lary's Waterloo". June 29, 1933. (c) Bear Cliff Spring, northeast of Mountain Lake. June 30, 1933: several specimens under stones. (d) Small spring on the west bank of Mountain Lake. July 13, 1933: numerous immature specimens. (e) Spring on the north side of the lake, near the place where the carriage road proceeding along the east bank starts. Spring almost dry, somewhat marshy, with many dead leaves. November 23, 1931: one immature specimen. (f) Small spring on the east slope of Salt Pond Mountain, southeast of Mountain Lake, tributary of Johns Creek. Cold, clear water, muddy bottom with stones. July 16, 1933: one mature and several immature specimens. (g) Johns Creek, upper part, east of Mountain Lake. Clear, cold water. July 16, 1933: one immature specimen.

(12) Mountain Lake, Giles County. On the east bank of the lake, near the pump. June 27, 1933: several specimens under stones.

(13) Spring on the road Newport-Mountain Lake, Giles County. About 5½ miles from Newport, at an altitude of approximately 3500 feet. April 18, 1932: several specimens (coll. Dr. Paul R. Burch).

(14) Creek about 2 miles from Newport, Giles County, on the road Newport-Mountain Lake. August 8, 1932: numerous immature animals collected under stones.

(15) Spring near Camp Kewanzee, Apple Orchard Mountain, 17 miles from Bedford, Bedford County. Small creek and marshy spring near the camp. Water cool and clean. November 22, 1931: several specimens, one of them mature, collected under stones.

(16) Cave Spring near Lexington, Rockbridge County. Creek springing from a small cave close to the North River, northwest from Lexington. Water cool and clear. May 16, 1932: one immature specimen found under a stone after long searching.

(17) Miller's Spring near Kerr's Creek, Rockbridge County. Spring near the highway Lexington-Rockbridge Baths, about 9 miles northwest from Lexington. Swiftly running, cool and clean water, bottom with stones. May 16, 1932: a few immature specimens among numerous *Fonticola morgani* var. *polycelis* collected.

(18) Spring near Amsterdam, Botetourt County. Spring on Frank Preston Farm, about 16 miles from Roanoke. April 22, 1932: several immature specimens collected on a piece of wood lying in the stream.

(19) Spring near Endless Caverns, Rockingham County. The same locality as that where *Fonticola gracilis* was collected. June 24, 1932: A few immature specimens collected under stones.

(20) Blue Spring in the Gorge on the Bullpasture River, between Clovercreek and Williamsville, about 10 miles from McDowell, Highland County. Swiftly running, clean, cool creek, bottom with stones. June 6, 1932 (water temperature 11.1°C.): one immature specimen.

(21) Spring 3 miles from Hot Springs, Bath County. Spring beyond the Cascades at Cascades Inn. September 11, 1932: several immature specimens (coll. Miss Ada A. Blanco).

(22) Crabtree Falls, northwest from Lovingston, Nelson County. Swiftly running, clear creek, not very cool. June 5, 1932: several immature specimens collected under stones.

(23) Little Falls Stream, on the old "King's Highway", near Fredericksburg. May 5, 1933 (coll. Dr. Wm. A. Kepner).

REPRODUCTION: In nature one mostly finds only small and immature animals; mature ones may be collected particularly in cool springs and, during the spring, also in creeks. Occasionally one observes signs of recent asexual reproduction, such as an area of regenerating tissue at the posterior end, and a posterior position of the pharynx. From these facts I conclude that reproduction takes place chiefly in an asexual way. In the laboratory, however, I always succeeded in inducing the formation of sex organs by keeping the cultures at low temperatures (10–12°C.) and feeding them well. At indoor temperatures the cultures survived but a short time; the animals, in this case, showed a tendency to break up at different levels of the body. The pieces, kept under favorable conditions, occasionally gave rise to new individuals; nevertheless, the

whole process gave an impression of a pathological division rather than of a normal fission.

In view of the fact that sexual organs develop at low temperatures, we may assume that the type of propagation in natural surroundings is controlled chiefly by this factor. Low temperatures may induce sexual reproduction, high temperatures may bring about asexual fission. In springs and creeks with varying temperatures the animals will lay cocoons during the cold season and propagate asexually during the summer. In cool springs, where the temperature is almost constant all the year round, and in creeks at relatively high altitudes, the period of sexual activity may be longer.

Under laboratory conditions, mature animals frequently deposit egg capsules. During the formation of the capsule in the genital atrium an aggregation of cell material in this region may even show externally. Later on the cocoon assumes a reddish brown color and shows through the body wall. After deposition, the cocoon darkens and becomes darkly brown. It is unstalked, spherical or elliptical, its longer diameter on an average amounting to about 1.5 mm., its shorter diameter to somewhat less. Maximum dimensions 1.95 x 1.77 mm., minimum size 1.23 x 1.02 mm., respectively.

A cocoon that I opened contained 14 embryos.

TAXONOMIC POSITION: *Fonticola morgani* is apparently closely related to the typical representatives of the genus *Fonticola* and has also been classed with this genus by Hyman (1931b, p. 328). It differs, however, from the forms so far comprised in this genus, the typical species of which is *F. olivacea* (O. Schmidt). In these species the zone of the testes extends backwards almost to the posterior end, while in *F. morgani*, the testes are situated only anteriorly to the copulatory organs. Hyman has already pointed out this peculiarity.

I am inclined to consider these features as characteristic of a natural group of species; this seems to be confirmed by a narrower geographical distribution of the group. In any case, the forms of this group represent a link between the genera *Fonticola*, which they resemble most closely, and *Polycelis*, from which they differ by the number of eyes. In order to include them with the genus *Fonticola*, the definition of this genus would have to be extended. Indeed, the posterior limit of the zone of testes does not appear significant enough to establish a new genus on the base of it alone, since the other anatomical features in no way decline from the general plan characteristic of the typical species of the genus *Fonticola*. I therefore adopt Hyman's (1931b, p. 328) proposi-

tion to change the definition of this genus, so that it would read as follows:

Genus *Fonticola* Komárek: *Planariidae* whose oviducts—without embracing the stalk of the bursa copulatrix—unite in a common oviduct which opens into the genital atrium. Male atrium without radial muscle plates. Adenodactyls absent. Eyes usually two (exception: *F. morgani* var. *polycelis*). Type of the genus: *F. olivacea* (O. Schmidt).

Fonticola morgani var. **polycelis,** n. var.

GENERAL FEATURES (Figs. 7, 12, 18): This variety differs from the type by the number and the arrangement of the eyes. The type, as already described, has two principal eyes, and occasionally single secondary eyes as well. In the variety *polycelis*, however, the number of eyes is very large. The other anatomical features are the same in both forms.

The eyes are arranged in two bands, lying close together, one on each side of the median line, and extending parallel or slightly converging anteriorly. Within each band the eyes are distributed irregularly, not arranged exactly in one row. The length of the bands varies somewhat in specimens from different localities, but is fairly constant for each locality. The posterior end of the bands is at about the level of the anterior end of the anterior intestinal ramus; anteriorly, the limit is not so constant: in specimens from Waynesboro the bands occupy about one-fourth to one-half of the length of the pre-intestinal region of the body, in animals from Miller's Spring about two-thirds and in those from Big Spring three-fourths or even more of that length.

The number of eyes varies considerably. In general, young (small) specimens possess fewer eyes than old (big) ones. In specimens of different size, both mature and immature, all collected in Big Spring, I counted the numbers shown in Table 1.

Only exceptionally the number is the same on both sides. Sometimes the eyes are arranged so densely that it is difficult to count them. The eyes are of different sizes (see Fig. 18): besides large or I may say "normally" developed eyes, smaller or larger spots of eye pigment occur. It appears doubtful as to whether these spots actually represent functioning eyes. I am inclined to attribute an optical function only to the larger eyes of typical shape.

In this variety it can be observed that the eye pigment is being constantly renewed. In whole mounts one sees clots and granules of pigment lying in the parenchyma between the eyes and apparently being eliminated from them. These presumably pass backward towards

the branches of the intestine and enter the digestive epithelium. The anterior branches usually contain a large number of dark granules which by their size and color prove to be eye pigment (Fig. 18).

Similar phenomena have been observed in *Dendrocoelum album* (= *Polycladodes alba*; see Kenk, 1926, p. 179) and in other species. It seems that, generally, the eye pigment in planarians is either constantly or periodically renewed (cf. Ghisalberti, 1919) and the old one eliminated (or digested?) by the intestine.

ECOLOGY AND DISTRIBUTION: The variety *polycelis* occurs in localities similar to those where the type of the species is found. It is, however, rarer than the type.

TABLE 1

LENGTH OF THE PRESERVED ANIMAL	NUMBER OF SPECIMENS	NUMBER OF EYES			
		Minimum on one side	Maximum on one side	On both sides	Average on both sides
mm.					
1–2	11	3	29	7–49	19.1
2–3	10	11	34	23–65	41.7
3–4	7	13	45	29–83	50.0
4–5	9	17	67	35–126	65.9
5–6	1	25	27	52	52
6–7	1	36	39	75	75
Among them 5 mature animals, 4–7 mm. long.....	5	20	66	44–126	69.8

Distribution in Virginia:

(1) Big Spring, near Kerr's Creek, Rockbridge County. The same locality as that where *Euplanaria tigrina* was collected. Enormous numbers of specimens on the lower surface of stones in the springs themselves and in adjacent parts of the pond. September 11 (water temperature 15°C.) and October 11, 1931 (15.2°C., pH 7.2), May 16 and 22, 1932: mature and immature specimens.

(2) Miller's Spring, near Kerr's Creek, Rockbridge County. The same locality as that where the typical *Fonticola morgani* was collected. May 16, 1932: numerous mature and immature specimens under stones.

(3) Creek near Waynesboro, Augusta County. The same locality as that where *Curtisia foremani* was collected. March 26 and April 3, 1932: numerous mature and immature specimens collected under stones.

TAXONOMY: According to the exact wording of the definition of the genus *Polycelis* (Kenk, 1930b, p. 294) *Fonticola morgani* var. *polycelis* ought to be classed with this genus. On the other hand, the perfect conformity with the typical *Fonticola morgani* as regards the anatomical

structure, as well as the existence of transitional forms, excludes any doubt of the close relationship to the latter species.

This case clearly shows that the number of eyes in planarians is of secondary significance as a generic characteristic and that it ought to be avoided in generic definitions, whenever possible. It appears necessary to distinguish the genus *Polycelis* from related genera by more accurate features. This, however, can be done only after an extensive comparative study of the species ranking in this genus.

Typical locality of *Fonticola morgani* var. *polycelis*: Big Spring near Kerr's Creek, Rockbridge County.

Planaria dactyligera, n. sp.

EXTERNAL FEATURES: Sexually mature specimens attain a length of 13 mm. and measure about 1.75 mm. across the widest part. The dorsal surface is darkly pigmented; the color may vary from almost black to a dark brown or gray. The ventral surface is somewhat lighter than the dorsal, usually gray. The pigment is almost uniformly distributed, without showing definite spots or stripes, at most a faintly clouded effect. Only a small area above each eye is free from pigment and frequently the situation of the copulatory organs (particularly of the adenodactyl) may be marked by a slightly lighter pigmentation of the dorsal surface above them.

The general shape of the animal, when gliding along undisturbed, is shown in Figures 5 and 13. The anterior outline is truncated. During locomotion the front margin of the head is subject to slight modification, the median part occasionally projecting a little. The lateral edges of the head are rounded, forming obtuse auricular projections. Behind these a very insignificant incurving may be observed in gliding animals. Then the body increases to the zone of maximum width and after that tapers gradually to the rather pointed posterior end.

Planaria dactyligera has normally two eyes, placed relatively far behind the anterior end; their distance from each other amounts to about one-third of the body width at the eye level, while their distance from the front end is a little less than the body width.

The basis of the pharynx lies near the middle of the body and the pharynx covers approximately one-third of the length of the posterior half of the body. The second third is occupied by the copulatory apparatus.

STRUCTURE OF THE SKIN: The structure of the surface epithelium shows no peculiarities.

The body pigment appears to consist of brownish black pigment

granules enclosed in ramified cells of the parenchyma. These are situated close to the surface epithelium, between the fibers of the external body musculature and penetrating but little towards the deeper layers (only as far as the layer of the rhabdite-forming cells).

On the ventral side of the head there are numerous openings of gland cells. They cover an elongated area along the median line behind the zone of the marginal adhesive cells. Their secretion is slightly eosinophilic. I have not been able to establish any particular differentiation in the muscular layers in this part. Nevertheless, this area presumably represents a primitive adhesive organ, such as is not uncommon among the triclads. Characteristic of the marginal epithelium just referred to is the depressed position of, at least, the greater number of the nuclei.

DIGESTIVE SYSTEM: The structure of the pharynx exhibits the arrangement typical for the family *Planariidae*: the circular and longitudinal fibers of the inner muscular zone form distinct layers. The outer muscular zone lacks a second (inner) layer of longitudinal fibers.

The branching of the intestine cannot easily be studied in living specimens because of the dark pigmentation of the body. In longitudinal sections I counted 6 to 7 lateral branches on the anterior ramus.

SENSE ORGANS: There are usually two eyes. Single supernumerary eyes may occur, but are smaller than the "principal eyes." The retina consists of a fairly large number (at least 15–20) of optical elements.

The head is provided with a pair of strips of modified surface epithelium, which I consider to be auricular sense organs. These lie along the frontal margin on each side, between the edge of the head and the submarginal adhesive zone. Their cells contain only few rhabdites and the nuclei occupy a normal position (in other species, the auricular sense organs frequently show depressed nuclei).

REPRODUCTIVE SYSTEM (Figs. 25 and 27): The numerous testes may be rounded or polygonal and occupy the ventral part of the body. Only occasionally some of them rise towards the dorsal side. They form a broad band on each side of the anterior ramus of the intestine and of the pharyngeal pocket, respectively. Each band is stretched above the ventral nerve cord of that side, overlapping it both medially and laterally. It extends from a short distance behind the ovary to about the level of the mouth. In a transverse section, from 3 to 5 testes may show in each band.

In the anterior half of the body, the vasa deferentia are narrow ducts with thin walls. They are not quite straight and follow the line of the ventral nerve cords on their medial sides, not closely attached to them

and also slightly removed from the ventral body musculature. They are connected with the testes by extremely fine tubules (vasa efferentia) which are longer or shorter, according to the distance of the testis from the vas deferens. Some testicular follicles open directly into the latter. The vasa efferentia of the testes situated on the outer side of the ventral nerve pass over the nerve cord to reach the vas deferens.

In the region of the pharynx, the vasa deferentia expand into large tubes filled with sperm (false seminal vesicles). They proceed in a winding course to the penis bulb and enter it, usually asymmetrically (the one more dorsally than the other). After a few more loops within the bulb they open united, or at least close to each other, into the seminal vesicle.

The ovaries (germaries) are in the normal position behind the cerebral commissure and medial to the ventral nerve cords. On their lateral and dorsal sides there are lobate masses of cells closely packed together. These may represent "parovaries" such as occur in many planarians. They consist partially of undifferentiated cells with darkly stained plasma, partially they are clearly differentiated into yolk cells. It has been repeatedly assumed that parovaria and yolk glands are related organs. This is confirmed once more by the structure of the parovary in our species.

The oviduct starts from the lateral part of each ovary and proceeds caudally above the ventral nerve cord, with yolk glands attached to the greater part of it. At the level of the copulatory organs it turns inward and dorsally, and unites with the oviduct of the other side, the left one passing between the bursa stalk and the wall of the genital atrium. Then the common oviduct descends ventrally and more or less caudally to open into the posterior part of the "male" atrium. The terminal parts of the separate oviducts and the upper two-thirds of the common oviduct are both connected with shell glands.

The genital atrium (Fig. 27) is small and almost entirely limited to the male atrium fitting the shape of the penis. A well-defined common atrium is absent, since the bursa stalk and the adenodactyl open almost independently through the genital pore. The atrium is lined with a cubical ciliated epithelium. Under it there is a layer of circular muscles and beyond that one of longitudinal muscles.

The penis consists of a relatively well developed bulb and a pointed cone-shaped papilla. The musculature of the bulb forms concentric layers of fibers, particularly in its peripheric parts. The bulb contains the curved ends of the vasa deferentia and the seminal vesicle. The

papilla or penis itself is covered by a flattened epithelium. The wall is provided with two layers of muscle fibers, a circular and a longitudinal one. The seminal vesicle merges into the ejaculatory duct without a definite boundary. The latter proceeds straight to the end of the penis, tapering gradually towards the point. The epithelium of the vesicle and of the anterior part of the duct is thick, but gradually flattens posteriorly. It is penetrated by numerous gland ducts containing a granular, faintly eosinophilic secretion. The gland cells to which these ducts belong, are situated outside the penis in the parenchyma surrounding the penis bulb.

The bursa copulatrix is a voluminous sac, lying immediately in front of the penis bulb. Its structure does not decline from the usual norm. The rather narrow bursa stalk proceeds slightly to the left side of the mid-line. It does not present any definite regions such as are found in several other planarians. Its lumen is lined by a very thick epithelium with villus-like projections. These probably perform a glandular function. Externally the stalk is coated with two layers of muscle fibers: circular fibers immediately under the epithelium, longitudinal muscles outside the former.

Adenodactyl: Particularly interesting is the presence of a well-developed adenodactyl or muscular gland organ. In a recent paper, Hyman (1931a, p. 126) calls attention to the fact that none of the North American species known so far possesses adenodactyls. Our species is, therefore, easily recognizable by this organ.

The adenodactyl is a highly muscular, ovoid organ situated behind the atrium, its longer axis extending obliquely from posterodorsal to anteroventral. Its musculature consists chiefly of circular fibers. The lumen is quadrangular in cross section and opens through the point of a small projection (papilla) into the atrium immediately near the genital pore. When the animal is fully mature, this cavity is entirely filled with glandular secretion which in the preparations appears darkly stained (blue or violet after staining with hematoxylin and eosin). In younger specimens a cubical ciliated epithelium is seen lining the cavity. The glands emptying into it lie in the parenchyma and their outlets penetrate the muscular layer as well as the inner epithelium. The whole organ is connected with the ventral body wall by single muscle fibers: these evidently perform the rôle of protractors. The function of this organ as well as of similar organs in other triclads is still doubtful.

ECOLOGY AND DISTRIBUTION: *Planaria dactyligera* occurs in cold water springs and in spring-fed ponds. It may be found on the lower

surfaces of stones or among water plants. Sometimes it is seen moving over the bottom of a pond even in the day-time.

Distribution in Virginia:

(1) Big Spring, near Kerr's Creek, Rockbridge County, i.e. the same locality where *Fonticola morgani* var. *polycelis* and *Euplanaria tigrina* were collected. In the springs, its occurrence among *F. morgani* var. *polycelis* is comparatively rare, but at a short distance from the springs, in the pond itself, it markedly predominates. September 11 and October 11, 1931, March 2 (coll. Dr. William A. Kepner), May 16 and 22, 1932: both young and sexually mature specimens collected. Egg capsules were brought into the laboratory with samples of mud and water plants.

(2) Mountain Lake, Giles County. (a) South bank, at the fish pool, below Mountain Lake Hotel. August, 1931 (coll. Mrs. Jeanette S. Carter). (b) East bank, near the pump. June 27 and July 13, 1933: numerous specimens under stones. (c) North bank, near the boat house. July 7 and 13, 1933: under stones.

(3) Pond on the left bank of Bullpasture River, about 5 miles below McDowell, Highland County. Small spring-fed pond with rich vegetation, ground swampy. June 6, 1932: several specimens brought into the laboratory in samples of mud (coll. Mr. C. M. Gilbert).

(4) Swamp near Rio, about 3 miles from Charlottesville, Albemarle County. June 6, 1932: several specimens (coll. Mr. T. K. Ruebush).

REPRODUCTION, DEVELOPMENT: The species apparently occurs sexually mature during all seasons of the year. It may be kept in the laboratory for a long time, but seems to require clean water and low temperature. Four specimens raised in a refrigerator at 10–12°C. and well fed on beef liver, laid 34 egg capsules during the period from January 31 until August 15, when the culture had to be discontinued. However, the period of sexual activity seems to be exceedingly long in this species.

The cocoon is elliptical or—more rarely—spherical, and unstalked. The size varies considerably: the biggest cocoon I measured attained 1.46 mm. (long axis) x 0.99 mm. (short axis), the smallest 0.68 x 0.65, a small, almost spherical capsule measured 1.23 x 1.12 mm. The freshly laid cocoon is yellowish brown, but soon darkens and, after a few days, appears darkly reddish brown. It is attached to the substratum by a transparent colorless jellylike substance in which it is also embedded (see Fig. 19).

The number of embryos in one egg capsule is subject to wide variation, from one to eight. This fact suggested dependence of the number of embryos on the dimensions of the egg capsule, especially upon its volume. Therefore I measured 28 cocoons collected in the field (Big Spring, October 11, 1931) and calculated the volume. This may be

obtained without a serious mistake by using the formula for an ellipsoid: volume $= \frac{\pi}{6} \times d^2 \times D$, d and D being respectively the short and the long axis of the egg capsule. The volume so established ranged from 0.150 to 0.807 mm³., an average of 0.417 mm³. From two of these cocoons, no animal hatched, from one of them, one animal hatched, leaving a voluminous mass of dead cell material in the capsule; these three cocoons I had to eliminate from the calculation. The remaining 25 cocoons showed an apparently normal development. The results are given in Table 2.

As far as we may judge from these scanty data the number of egg cells in a cocoon really seems to be to a certain degree in correlation with its size.

On the other hand, the quantity of yolk material apportioned to each egg cell may determine the size of the young animal. The more yolk at its disposal, the larger the embryo may grow within the egg capsule. Indeed, one observes considerable differences between hatching animals, their length varying from 1.28 to 3.8 mm.

TABLE 2

Volume of cocoons	0.150–0.399 mm³.	0.4–0.807 mm³.
Number of cocoons	11	14
Number of animals hatched	30	51
Average number of animals per cocoon	2.73	3.64

When the animals leave the cocoon, they are without body pigment, entirely white; only the two small black eye spots are developed. During the following days they gradually become pigmented and exhibit a grayish or brownish appearance. The pigment formation is apparently controlled to a certain extent by the light: animals kept in the dark appeared markedly lighter than others of the same age raised in daylight (cf. Perkins, 1929, p. 759).

TAXONOMY: *Planaria dactyligera* differs from the species now comprised in the genus *Planaria* by only one important characteristic. The representatives of this genus, as defined in an earlier paper (1930b, p. 293), show the zone of testes extending almost to the posterior end; in the new species, however, testes are developed only anteriorly to the copulatory organs. On the other hand, the structure and position of the well-developed adenodactyl in the new species reveals, in my opinion, a true relationship with the genus *Planaria*. I therefore prefer to extend the definition of this genus, which would then be as follows:

Genus *Planaria* O. F. Müller: *Planariidae* whose oviducts—without embracing the stalk of the bursa copulatrix—unite in a common oviduct which opens into the genital atrium. Male atrium without radial muscle plates. Adenodactyl present, constructed according to the *Planaria torva* type. Type of the genus: *Pl. torva* (O. F. Müller).

Typical locality of *Planaria dactyligera*: Big Spring, near Kerr's Creek, Rockbridge County, Virginia.

Procotyla typhlops, n. sp.

The genus *Procotyla* was hitherto represented by one single species, viz., *Procotyla fluviatilis* Leidy. This species has been for a long time confused with the European *Dendrocoelum lacteum*, but is definitely different from the latter and marked by several peculiarities especially with regard to the male reproductive organs. An extensive account of its morphology and ecology was recently published by Hyman (1928). This paper also throws light on the rather puzzling rôle played by this species in the literature concerned; since now *Procotyla fluviatilis* ranks among the best known North American planarians. I shall have to refer repeatedly to Hyman's paper.

Procotyla typhlops resembles *Pr. fluviatilis* in many respects. It shows, however, several marked differences.

EXTERNAL FEATURES: Mature specimens, when fully distended, attain a length of 12 mm. and a greatest width of 1.33 mm. The species is considerably smaller and more slender than *Procotyla fluviatilis*.

The body lacks pigment and appears white in fasting animals. When the intestine is filled, its contents show through the body wall changing the general color of the animal to a reddish or brownish hue. Nevertheless, the head, the edge, the regions of the proboscis and of the copulatory apparatus remain milky white. There are no eye spots.

The anterior end (Figs. 8, 14) is truncate, the frontal margin running transversely, the middle part occasionally slightly protruding. On its ventral surface, a very faintly indicated adhesive organ may be discerned. I shall presently return to the structure of this organ. The lateral edges of the anterior margin are rounded, very slightly projecting laterally; so we may call them auricular appendages. Behind them a very slight constriction of the lateral margins may be observed. Then the body widens gradually and evenly to attain the greatest width only at about the middle of the body length. Behind the level of the copulatory organs the margins converge. The posterior end appears sometimes pointed, sometimes rather blunt while the animal is in motion.

The root of the pharynx is situated at about the middle of the body or

somewhat posteriorly to it. The copulatory organs in fully mature specimens occupy about two-thirds of the postpharyngeal region.

THE SURFACE EPITHELIUM is formed on the usual plan. I want to discuss only a few peculiarities of the body margin and the anterior end. The epithelium of the margin is taller and its cells are densely filled with rhabdites, which also appear taller than those from other regions of the surface; similar conditions have been found in *Procotyla fluviatilis*. The usual zone of adhesive cells is situated below the edge of the margin. It consists of a strip of "depressed" epithelium destitute of rhabdites and perforated by numerous outlets of eosinophilic glands. In most of the fresh-water planarians this strip forms a continuous border along the entire margin of the body. In our species, however the adhesive strip, slightly widening towards the anterior end, is interrupted in two spots symmetrically placed one on either side of the ventral surface of the head. Identical conditions are reported by Wilhelmi (1909, p. 158) to occur in marine triclads. The short middle portion of the adhesive zone, disconnected from the lateral and posterior part, represents a primitive adhesive area. It is comparatively broad, but as far as its structure is concerned, it is the same as the main adhesive strip. I have not succeeded in discovering any modification of the muscular layers of the body wall in this place. Presumably, its function is to adhere to the substratum by means of its sticky secretion. It may be used this way in crawling locomotion and also in the capturing of prey.

The other species of the genus *Procotyla*, *P. fluviatilis*, possesses a highly developed sucker instead of a simple adhesive area. This organ performs both a glandular and muscular function. Nevertheless, in this species also the adhesive strip presents interruptions on both sides of the sucker, similar to those in *P. typhlops*. This fact suggests that the highly complicated sucker or grasping organ of *P. fluviatilis* evolved from a definite part of the marginal adhesive zone by gradual differentiation of the glandular structures and by a local modification of the muscular systems in its vicinity, particularly of the longitudinal muscle layer of the ventral body wall. The different structure of the adhesive organ in these two, very closely related, species shows that even well-developed suckers may be quoted for taxonomic conclusions only upon careful consideration. It is already well known that in different species of planarians all transitional stages occur, from primitive glandular areas to definite muscular adhesive organs.

DIGESTIVE SYSTEM: The pharynx is rather short, amounting to about one-tenth of the entire length of the body. It is built on the plan charac-

teristic of the family *Dendrocoelidae*: The inner muscular zone consists of intermingled layers of circular and longitudinal muscle fibers. Its external muscle zone consists of only two layers, a longitudinal and a circular one; a second, incomplete, layer of longitudinal muscles, such as is developed in several other *Dendrocoelidae*, is absent. The mouth is situated at the posterior end of the pharyngeal chamber.

The intestine presents the usual three main rami. Frequently the two posterior rami unite behind the copulatory organs, and form a median posterior ramus. On the other hand, they may be entirely separate. The number of lateral branches is subject to some variation: On the anterior ramus, there are 10–12, on each posterior ramus 15–21 lateral branches. The formula of the branching is, therefore: 15–21, 2(10–12), 15–21.

SENSE ORGANS: All traces of eyes are absent, as has been mentioned before.

The auricular sense organs cannot be seen in living animals. In microscopic preparations, however, I have observed structures at the anterior end which I believe to be such organs. There is one marginal strip of modified surface epithelium on each side of the median line, situated approximately above the place where the submarginal adhesive zone is incomplete. The epithelium there is of the normal structure (the nuclei not being depressed below the basement membrane), but lacking rhabdites and provided with very well developed cilia. These strips occupy exactly the edge of the body, to some extent encroaching upon the dorsal and ventral surfaces. At their lateral ends they border on the tall marginal epithelium, with numerous rhabdites, while that part of the frontal margin that lies between their medial ends is coated with a cuboidal epithelium.

REPRODUCTIVE ORGANS (Figs. 26, 28): The testes are numerous, situated mostly dorsally, only a few approaching the ventral body wall. They form a rather narrow zone above the ventral nerve cord on each side of the body. This zone begins a short distance behind the ovary and extends posteriorly to the region of the pharynx.

From each testis a very fine vas efferens leads into the longitudinal vas deferens. The latter is a narrow thin-walled canal passing close to the dorsal side of each ventral nerve cord, slightly medially to the oviduct. At the level of the pharynx the vas deferens moves a little medially and abruptly expands into a rounded sac lined with a thin but distinct epithelium. This enlargement is filled with sperm and represents a "false seminal vesicle." A thin coiled tube runs from it back-

wards to the level of the penis bulb, turns to the mid-line and unites with the tube of the opposite side. The common vas deferens or seminal duct then expands again, swollen with sperm, and forms several loops below the anterior part of the penis bulb and in front of it. Physiologically, this enlarged part performs the same function as the false seminal vesicle. The tube finally narrows again and enters the penis bulb at its anterior end.

The ovaries and oviducts present the usual structure and position: The ovaries are situated on the medial side of the nerve cords. The oviducts start from their lateral part with an enlarged section filled with spermatozoa: the seminal receptacle or tuba. Then they turn posteriorly and pass along the dorsal sides of the nerve cords, laterally to the vasa deferentia. They connect with yolk glands which abound in the parenchyma, lying both dorsally and ventrally to the intestine and between its lateral branches. Near the copulatory apparatus the oviducts turn inward and dorsally and unite in the space between the genital atrium and the stalk of the bursa copulatrix; the common oviduct thus formed proceeds ventrally and opens into the posterior part of the male atrium. Intensely stained eosinophilic glands (shell glands) empty into the upper part (about two-thirds) of the common oviduct as well as into a short adjoining portion (about 80μ long on each side) of the separate oviducts.

The genital atrium is relatively small and restricted almost entirely to the male atrium. This is conical in shape and contains the penis papilla or penis proper. Backwards it narrows into a short tube which proceeds posteriorly and on its dorsal side connects with the stalk of the bursa copulatrix. At the point of transition from the male atrium to the tube the common oviduct opens from above. After its juncture with the bursa stalk, the narrow atrial tube turns ventrally and ends at the genital pore. This short perpendicular part corresponds to a common atrium, but shows only a narrow lumen.

The epithelium of the male atrium appears rather flattened in the anterior section, near the basis of the penis; posteriorly it becomes cubical or even columnar. The cells there are of a very significant type, similar to those observed in *Procotyla fluviatilis* in the same place: the distal parts of the cells are closely packed with granules of glandular secretion which appear brilliantly red after staining with eosin or erythrosin; the basal portions of the cells lack such inclusions. The granules are formed by the epithelial cells themselves and are not emptied into them by external glands. No villus-like projections of the

epithelium, such as are described for *P. fluviatilis*, have been observed in this form.

The epithelium of the common atrium shows an entirely different structure. It is "depressed" and perforated by numerous outlets of eosinophilic glands which lie in the surrounding parenchyma.

The penis closely resembles this organ in *P. fluviatilis*. It consists of a relatively large bulb and of a small papilla or penis proper. The bulb is of elliptical shape and highly muscular. It contains a large cavity which is likewise elliptical and corresponds to a seminal vesicle. Its wall is formed by two muscular layers separated by a thin non-muscular layer. The external muscular layer, which is the thicker one, is composed of longitudinal muscle fibers running not exactly parallel to the main axis of the organ, but more or less obliquely from anterior and dorsal to posterior and ventral. The internal layer consists of circular fibers. The intermediate non-muscular stratum lacks distinct cell borders and nuclei. On closer observation one distinguishes minute fibers running in a circular direction and only very faintly susceptible to eosin. I call this stratum the fibrous layer. It is difficult to establish its exact histological structure. A similar structure may occasionally be found also in other species of planarians, e.g. in *Fonticola gracilis*, etc. Presumably it performs some mechanical function, as it appears to be both rigid and elastic.

In *Procotyla fluviatilis*, according to Hyman, the wall of the penis bulb consists of two longitudinal muscle layers separated by a mucous layer; the inner longitudinal layer corresponds to the circular layer of *Procotyla typhlops* and the mucous layer (the external mucous layer, as Hyman calls it) corresponds to our fibrous layer. This layer is more highly developed in *P. fluviatilis* than in *P. typhlops*.

The large cavity of the penis bulb is lined with a tall secretory epithelium, except for the posterior portion where the bulb merges into the papilla. The cells are club-shaped and almost entirely transformed into a faintly eosinophilic, finely granulated secretion which still shows the shape of the former cells. Unchanged protoplasm and nuclei remain only at the base of the epithelium, forming a thin and somewhat irregular lining. Similar masses of secretion occur in the lumen, but do not fill it entirely in my preparations. It is interesting that in *Procotyla fluviatilis* Hyman finds a free cavity only in young specimens, while in mature animals it is completely filled with mucus and thus appears solid throughout.

The penis papilla is conical, the posterior end often tapering off into

a finger-shaped and curved appendage. The wall is rather thin and includes a cavity which repeats the general shape of the papilla: anteriorly, where it passes over into the lumen of the bulb, it is wide, but gradually narrows posteriorly until it becomes a fine tube leading to the point of the papilla. The penis is coated with a flattened epithelium; immediately below this lies a fibrous layer which is continuous with the fibrous layer of the bulb; then follow longitudinal muscles continuous with the circular muscle layer of the bulb; and finally, the flattened epithelial lining which passes over into the secretory lining of the cavity.

The common vas deferens enters the penis bulb at its anterior part as a thin tube. It penetrates the muscular wall and proceeds posteriorly along the ventral mid-line of the organ, between the inner (circular) muscle layer and the epithelium lining the cavity. It is distended, filled with sperm, and projects slightly into the lumen. At the boundary between the bulb and the papilla it opens into the penis cavity. There is no special sphincter in this place. Hyman calls the corresponding tube in *Procotyla fluviatilis* the ejaculatory duct. In our case, where a distinct cavity is present, I prefer to call the canal a common vas deferens or seminal duct (Fig. 28, cvd) as it opens into the cavity. The ejaculatory duct is the short narrow lumen of the papilla. Morphologically considered, the cavity of the penis bulb corresponds to the seminal vesicle of other planarians; physiologically, however, it differs from this vesicle, since, most likely, it never contains any sperm. Its function is rather that of an accessory gland whose secretion is added to the sperm during the ejaculation. Woodworth (1897, p. 5) calls the corresponding structure in *Procotyla fluviatilis* the "prostate gland;" this name fairly indicates its actual function.

The bursa copulatrix is a voluminous sac of more or less varying shape. Its epithelium consists of big cubical cells provided with large secretory vacuoles. The outlet or stalk of the bursa starts from its posterior and dorsal part, runs posteriorly approximately above the penis, curves ventrally behind the male atrium and opens into the tube-shaped common atrium. The anterior part of the stalk is rather narrow and thin-walled, posteriorly it gradually widens and its epithelium becomes thicker; at the same time the thickness of its muscular coat increases. There is, however, no distinct boundary between the anterior and posterior parts of the stalk. The musculature consists of two layers: the circular muscles coating the epithelium and a layer of longitudinal fibers outside the former.

No adenodactyl or muscular gland organ is present.

ECOLOGY AND DISTRIBUTION: *Procotyla typhlops* has been collected in a cold limestone spring whose temperature seems to vary but little during the seasons of the year. It is found usually on the lower surface of stones. It is probable that the animal inhabits subterranean waters as well. The absence of eyes may be correlated with this habitat.

Distribution in Virginia:

(1) Big Spring near Kerr's Creek, Rockbridge County. In the same locality *Euplanaria tigrina* and other species were collected. *Procotyla typhlops* occurs in the springs themselves, but is rare in comparison with the other species. It also lives in the pond and one specimen was collected in the creek that is the outlet of the big pool. October 11, 1931, May 16 and 22, 1932: both young and mature animals collected.

REPRODUCTION: Sexually mature animals were collected in October and May. It is possible that the sexual organs develop during all

TABLE 3

PROCOTYLA TYPHLOPS	P. FLUVIATILIS
Body length attaining 12 mm.	Body length attaining 20 mm.
Adhesive organ feebly developed, represented by a glandular area.	Adhesive organ a true sucker, provided with glandular and muscular differentiations.
Eyes absent.	Eyes present, 1 to 8 on each side of the head.
Muscles of the penis bulb form an external longitudinal and an internal circular layer.	The muscular wall of the penis bulb consists of two layers of longitudinal muscles.

seasons of the year, since the nature of the locality presents but little variation in temperature all the year round. I never have seen any indication of asexual reproduction. Asexual (probably young) animals attained maturity after having been kept at a low temperature (10–12° C.) for some time, often amounting to several months. No egg capsules were deposited in the aquaria.

TAXONOMY: From a comparison of the anatomy of the new species with the structure of *Procotyla fluviatilis*, as described by Hyman (1928), we see that these two species are very closely related. There is a striking resemblance, particularly in the structure of the reproductive organs. The most significant differences are shown in Table 3.

It is interesting to note that Beauchamp (1931, p. 320) recently expressed his opinion that a blind species of *Procotyla* might be discovered in America.

Procotyla fluviatilis has hitherto been the only species of the genus

The characteristics of the new species *typhlops* render advisable a revision of the generic diagnosis that I have given in a former paper (1930 b, p. 296). The new diagnosis is as follows:

Genus *Procotyla* Leidy, 1857: *Dendrocoelidae* without adenodactyl; penis papilla present, penis bulb with two concentric muscular layers which are separated by a non-muscular layer. Oviducts unite in a common duct without embracing the stalk of the bursa copulatrix. Type of the genus: *P. fluviatilis* Leidy, 1857.

ECOLOGY AND DISTRIBUTION OF PLANARIANS IN VIRGINIA

Adopting the ecological classification of European planarians proposed by Steinmann (Steinmann und Bresslau, 1913, p. 151) and proved useful also in the case of other groups of aquatic animals, we may distinguish two groups of fresh-water triclads in Virginia; viz. (1) those which prefer running water and are therefore to be found in springs, creeks, and rivers ("rheophilic" forms) and (2) others inhabiting, chiefly, stagnant water, such as ponds, pools, and lakes ("limnadophilic" forms). There is, of course, no sharp demarcation between these groups, just as there is no definite demarcation possible between running and stagnant water. Furthermore, we have to bear in mind that the reophily is not the only factor controlling the distribution of planarians. Other characteristics of the habitat likewise play an important rôle, such as the temperature and the chemical composition of the water, the kind and quantity of the food supply, and, perhaps less decisively, the nature of the substratum. The mutual competition between different species likewise comes into consideration. All these factors and perhaps a few more besides are apt to influence the distribution of water animals in a given area.

Returning to the question of rheophily we may characterize the species as follows:

Rheophilic forms:

Fonticola morgani,
Procotyla typhlops,
Curtisia foremani,
Euplanaria dorotocephala.

Limnadophilic form:

Euplanaria tigrina.

Planaria dactyligera and *Fonticola gracilis* occupy an intermediate position with regard to their habitats in Virginia.

As to the relations between the temperatures of the water and the occurrence of planarians, it has been known for a long time that certain species may live well within a considerably wide range of temperature. It is probable that for each species, perhaps even for different physiological races of a single species, a certain optimum temperature exists, in which growth and propagation attain the highest rate. Nevertheless, some species tolerate a marked deviation from the optimum without detriment. Such forms are eurythermic. Others are rather sensitive to abrupt changes in temperature, particularly to sudden rises: these are stenothermic.

Speaking generally, rheophilic species are stenothermic and prefer low temperatures, whereas the limnadophilic ones are eurythermic. My observations in the field and in the laboratory do not suffice to provide an exact classification of the planarians of Virginia from this point of view. In any case, some species proved to be markedly stenothermic, such as *Procotyla typhlops* and *Fonticola morgani*. *Euplanaria tigrina* and *Fonticola gracilis* are decidedly eurythermic.

Among certain rheophilic forms, there seems to exist a rule of distribution, similar to that found in the European species *Crenobia alpina*, *Polycelis felina* and *Euplanaria gonocephala*. These three species occur, usually, in a definite succession: *Crenobia alpina* inhabits the springs and the upper parts of mountain streams, at lower altitudes it is replaced by *Polycelis felina*, which, still lower down, gives place, in its turn, to *Euplanaria gonocephala*. In transitional zones both neighbouring species are found together. This particular distribution appears to be due chiefly to the temperature of the water in different parts of the stream. The spring exhibits a rather constant temperature all the year round, while in descending the daily and seasonal amplitudes of the temperature increase in rate. Temperature is not the only factor involved, but seems to be the principal one.

In a similar way, *Fonticola morgani* occurs in Virginia in the springs and upper reaches of creeks; in the lower parts it is accompanied or even supplanted by *Curtisia foremani* and *Euplanaria dorotocephala*. *Fonticola morgani* also proceeds farthest upwards in the mountains. I have, however, not carried out an intensive investigation of the distribution of these species in a limited area. Any conclusions regarding successive immigrations of the species concerned, such as have been shown probable in the case of European forms, would be premature because of the scarcity of data available at present. Only a detailed study of the distribution of the various species and a rational applica-

tion of the geological history of the country would justify a more definite opinion.

In two Virginian species, viz. *Procotyla typhlops* and *Fonticola morgani*, subterranean habitat is very probable, though not really established as yet. *Procotyla typhlops* is a blind species found in a spring near Lexington. The blindness as well as the limited distribution suggest that it lives in subterranean waters of this limestone region. *Fonticola morgani* sometimes occurs in very small springs which dry up in the summer. It probably retires to the ground water during the dry season. In the few limestone caves in the Shenandoah Valley which I visited, I did not, however, collect any planarians.

SUMMARY

(1) In Virginia seven species and one variety of freshwater triclads were collected.

(2) The forms investigated are:

Curtisia foremani (Girard)
Euplanaria tigrina (Girard), syn. *Planaria maculata* Leidy.
Euplanaria dorotocephala (Woodworth)
Fonticola gracilis (Haldeman)
Fonticola morgani (Stevens and Boring)
Fonticola morgani var. *polycelis* n. var.
Planaria dactyligera n. sp.
Procotyla typhlops n. sp.

(3) Descriptions of the new forms are given and data concerning the old ones supplemented.

(4) The Virginian planarians are classified with regard to their ecology.

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EXPLANATION OF FIGURES

Figs. 1–8. Photographs of living animals taken by the method described in Science, n.s. **75**: 669–670. 1932.

Fig. 1. *Curtisia foremani* from Charlottesville, Va., × 6.6.
Fig. 2. *Euplanaria tigrina*. (a) From Sinclair's Pond, Charlottesville, Va., × 4.2. (b) From Big Spring near Kerr's Creek, Va., × 8.5. (c) From Park Spring Lake, Caswell County, N. C. (coll. Dr. Wm. A. Kepner), × 5.3.
Fig. 3. *Euplanaria dorotocephala* from Big Spring near Kerr's Creek, Va. (auricles somewhat raised), × 3.2.
Fig. 4. *Fonticola gracilis* from East Radford, Va., × 5.
Fig. 5. *Planaria dactyligera* from Big Spring near Kerr's Creek, Va., × 8.5.
Fig. 6. *Fonticola morgani* from a spring near Mountain Lake, Va., × 4.7.
Fig. 7. *Fonticola morgani* var. *polycelis* from Big Spring near Kerr's Creek, Va., × 5.3.
Fig. 8. *Procotyla typhlops* from Big Spring near Kerr's Creek, Va., × 7.6.

Figs. 9–14. Sketches of living animals. Abbreviations: *co.*, copulatory organs; *gp*, genital pore; *li*, limit of the area covered by the intestine; *m* mouth; *ph*, pharynx.

Fig. 9. *Curtisia foremani*, × 7.8.
Fig. 10. *Fonticola gracilis*, × 6.
Fig. 11. *Fonticola morgani*, × 9.2.
Fig. 12. *Fonticola morgani* var. *polycelis*, × 7.3.
Fig. 13. *Planaria dactyligera*, × 7.8.
Fig. 14. *Procotyla typhlops*, × 8.5.

Figs. 15 and 16. Abbreviations: *b*, bursa copulatrix; *bd*, bd_1, stalk of the bursa copulatrix; *ca*, common atrium; *cod*, common oviduct; *ed*, ejaculatory duct; gl_1, gl_2, outlets of glands; *gp*, genital pore; *i*, intestine; *m*, mouth; *ma*, male atrium; *od*, oviduct; *sgl*, shell glands; *sv*, seminal vesicle; *v*, vagina; *vd*, vas deferens.

Fig. 15. *Curtisia foremani*, diagram of the copulatory organs in longitudinal section, × 160.
Fig. 16. *Euplanaria tigrina*, diagram of the copulatory organs in longitudinal section, × 70.

Figs. 17–20. Abbreviations: *b*, bursa copulatrix; *bd*, stalk of the bursa copulatrix; *c*, egg capsule (cocoon); *cvd*, common vas deferens (seminal duct); *d*, disc of the stalk of the cocoon; *ed*, ejaculatory duct; *fl*, fibrous layer; *gp*, genital pore; *j*, jellylike substance surrounding the egg capsule; *ma*, male atrium; *od*, oviduct; *pb*, penis bulb; *php*, pharyngeal pocket; *st*, stalk of the cocoon; *sv*, seminal vesicle; *vd*, vas deferens.

Fig. 17. *Fonticola gracilis*, diagram of the copulatory organs in longitudinal section, × 56.
Fig. 18. *Fonticola morgani* var. *polycelis*, head (from a whole mount), × 141.

Fig. 19. *Planaria dactyligera*, egg capsule, × 17.
Fig. 20. *Euplanaria dorotocephala*, egg capsule, × 15.

Figs. 21–24. Abbreviations: *b*, bursa copulatrix; *bd*, bd_1, bd_2, stalk of the bursa copulatrix; *cgl*, cyanophilic glands; *cm*, circular muscles; *cod*, common oviduct; *ed*, ejaculatory duct; *gl*, outlets of glands; *gp*, genital pore; *i*, intestine; *m*, mouth; *ma*, male atrium; *mp*, muscular point of the penis; *n*. ventral nerve cord; *od*, oviduct; *ods*, oviduct of the left side; *oed*, opening of the ejaculatory duct; *pb*, penis bulb; *pp*, penis proper (papilla); *t*, testis; *vd*, vas deferens.

Fig. 21. *Fonticola morgani* (from Whiskey Creek, near Churchville, Va.), diagram of the copulatory organs in longitudinal section, × 95.
Fig. 22. *Fonticola morgani* (from a spring near Mountain Lake, Va.), diagram of the copulatory organs in longitudinal section, × 82.
Fig. 23. *Fonticola morgani* (the same specimen as in fig. 22), structure of the penis, × 82.
Fig. 24. *Fonticola morgani*, cross section through the prepharyngeal region, showing the situation of testes, vas deferens, and oviduct, × 35.

Figs. 25–26. Diagrams of the reproductive system. The female organs are shown on the left, the male organs on the right side. Yolk glands (vitellaria) are omitted. Abbreviations: *ad*, adenodactyl; *b*, bursa copulatrix; *fsv*, false seminal vesicle; *n*, ventral nerve cord; *od*, oviduct; *ov*, ovary (germary); *p*, penis; *pb*, penis bulb; *ph*, pharynx; *t*, testes; *vd*, vas deferens.

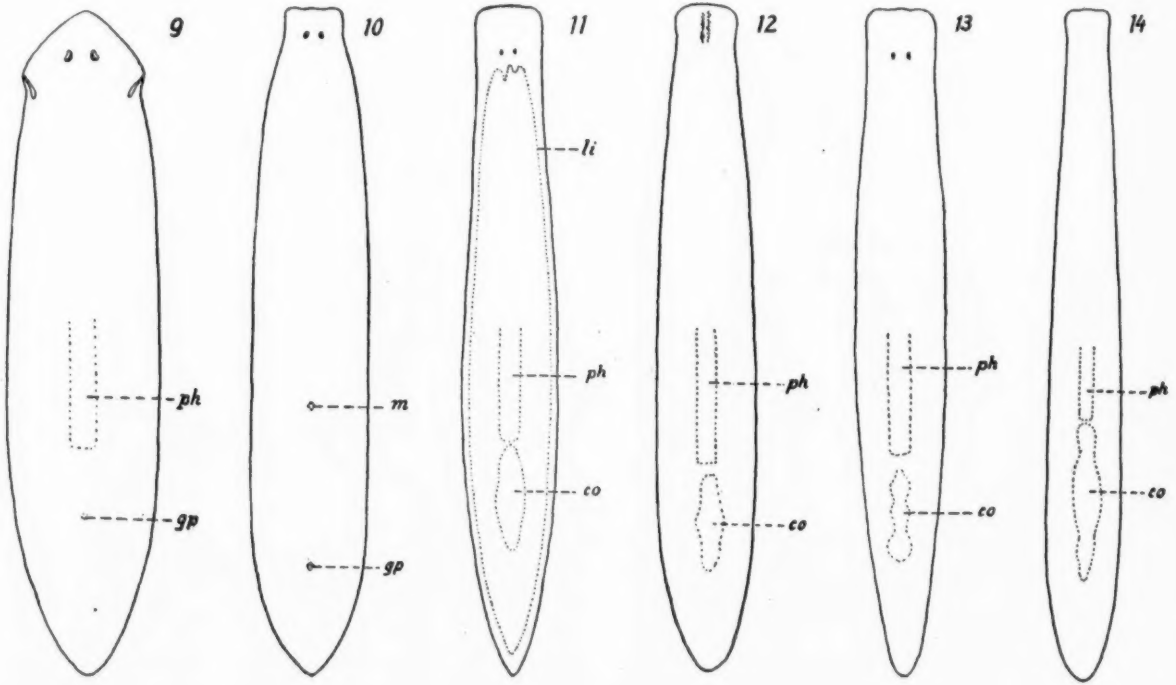
Fig. 25. *Planaria dactyligera*, × 13.5.
Fig. 26. *Procotyla typhlops*, × 14.5.

Figs. 27 and 28. Diagrams of the copulatory organs, drawn from longitudinal sections. Abbreviations: *b*, bursa copulatrix; *bd*, stalk of the bursa copulatrix; *cm*, circular muscles; *cod*, common oviduct; *cvd*, common vas deferens (seminal duct); *ed*, ejaculatory duct; *epr*, epithelial lining of the prostate; *fl*, fibrous layer; *gl*, outlets of glands; *gp*, genital pore; *la*, lumen of the adenodactyl; *lm*, longitudinal muscles; *m*, mouth; *ma*, male atrium; *od*, oviduct; *ods*, oviduct of the left side; *pgl*, penis glands; *pr*, prostate; *sv*, seminal vesicle; *vd*, vas deferens; *vds*, vas deferens of the left side.

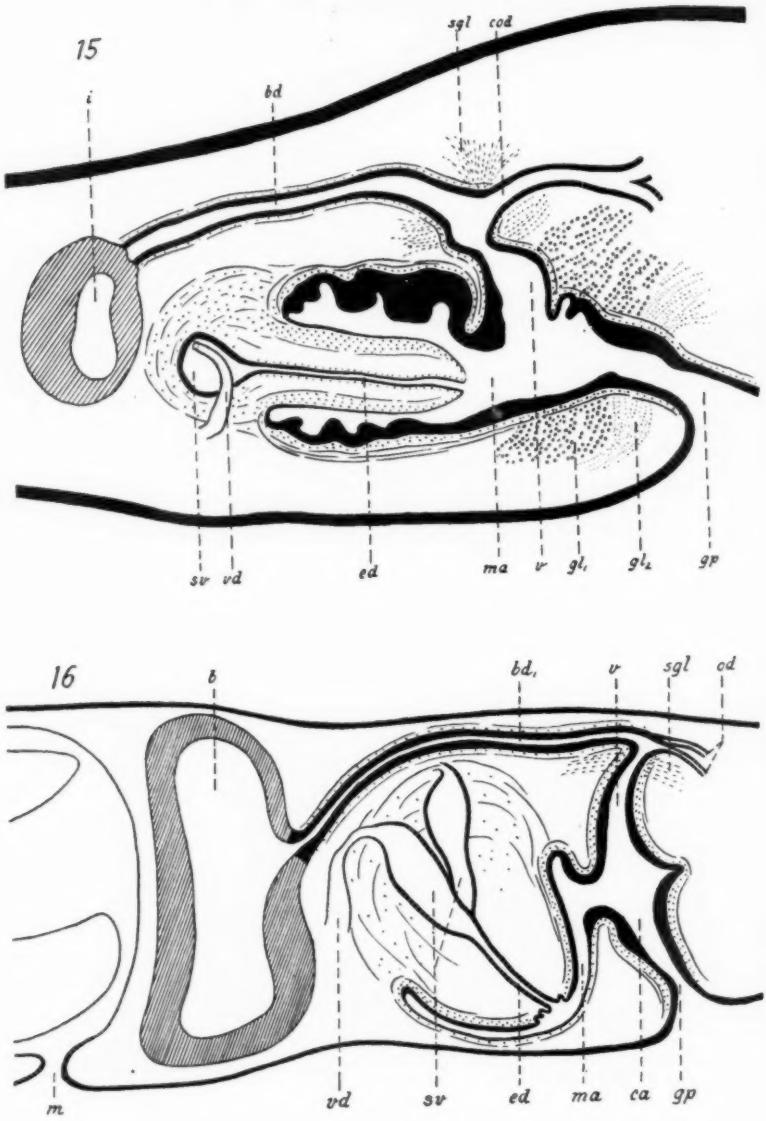
Fig. 27. *Planaria dactyligera*, × 115.
Fig. 28. *Procotyla typhlops*, × 98.

Fig. 29. Map of the state of Virginia, showing the distribution of planarians. The numbers correspond to the localities mentioned in the text. Localities lying close together are represented by a single sign accompanied by more than one number. The extreme western part of the state, where no planarians were collected, is omitted from the map.

PLATE 45



FIGS. 9–14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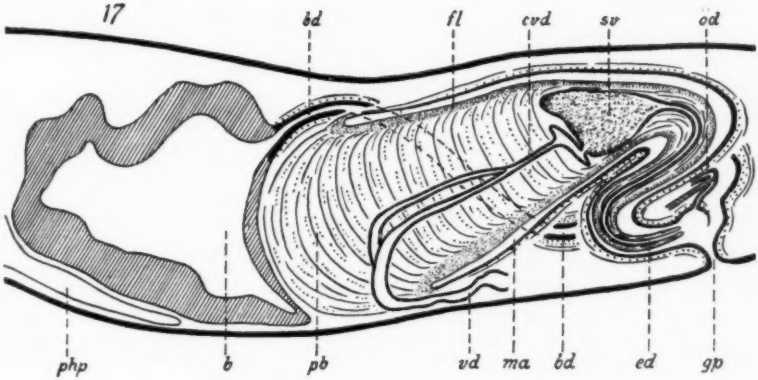
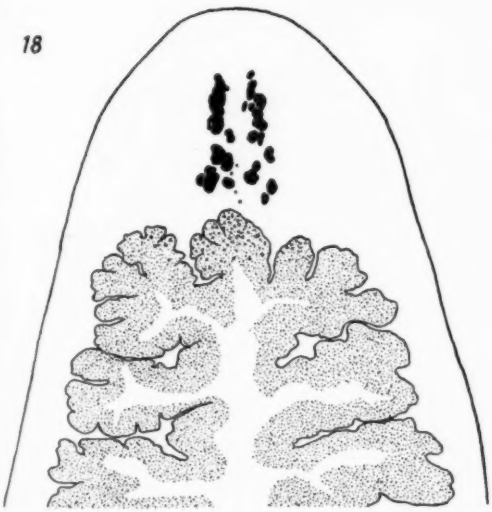
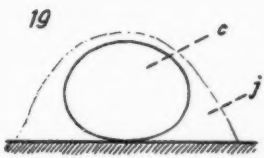
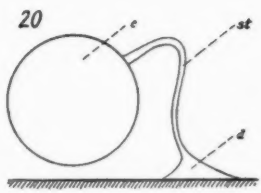
FIGS. 15–16

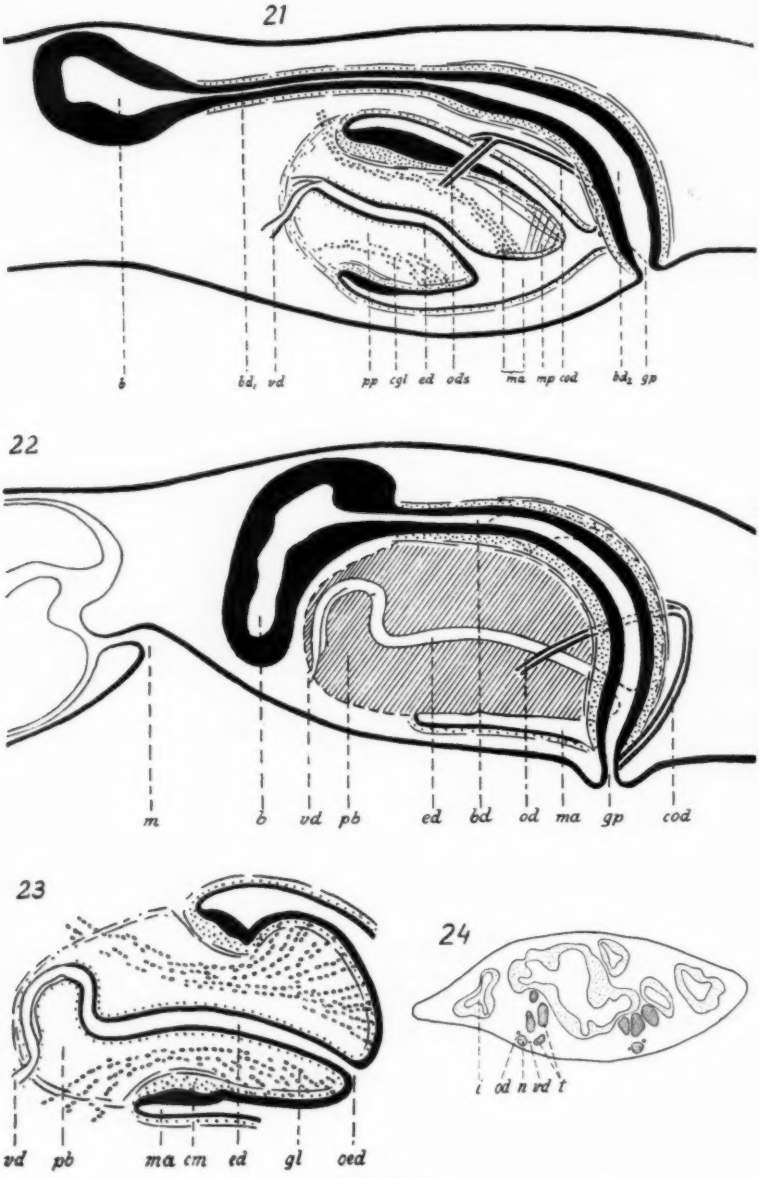








FIGS. 17–20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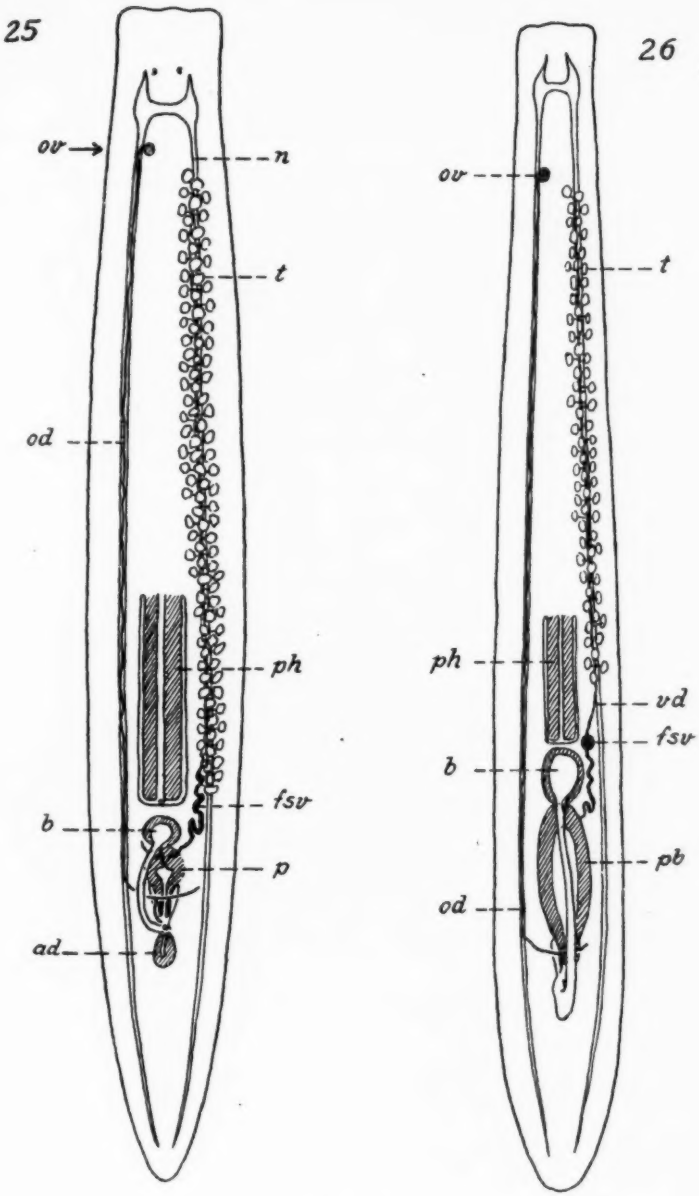
FIGS. 21–24



FIGS. 25–26

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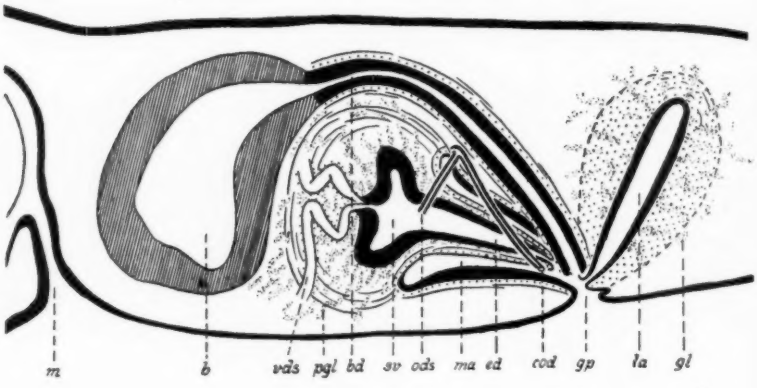

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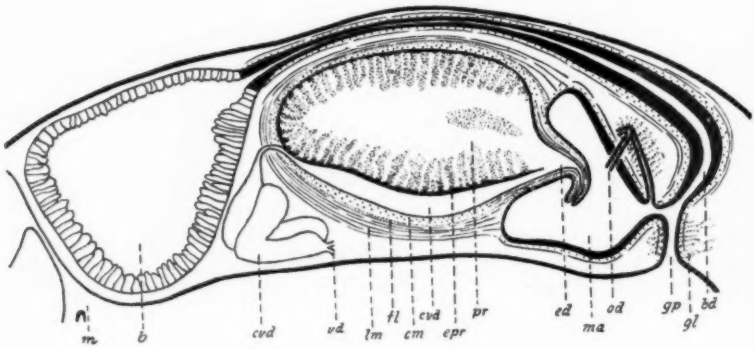

FIGS. 27–28

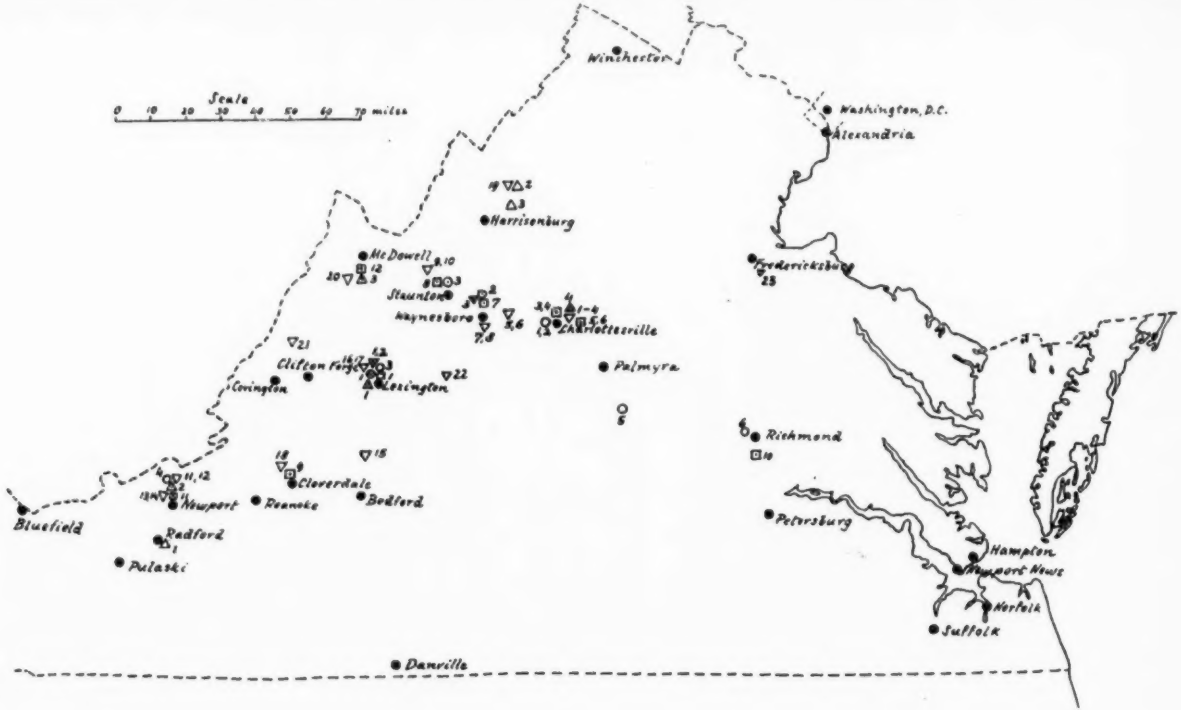

FIG. 29

- ⊡ *Curtisia foremani.*
- ○ *Euplanaria ligrina.*
- ⊙ *Euplanaria dorotocephala.*
- △ *Fonticola gracilis.*
- ▽ *Fonticola morgani.*
- ▽ *Fonticola morgani* var. *polycelis.*
- △ *Planaria dactyligera.*
- □ *Procotyla typhlops.*

INSPECTIONAL ANALYSIS: A METHOD WHICH SUPPLEMENTS DIMENSIONAL ANALYSIS

By Arthur Edward Ruark

Dimensional analysis has proved extremely useful in many fields of engineering and physics, especially since 1922, when access to its methods was made easy by the publication of Bridgman's "Dimensional Analysis" (1). It is significant that in this book much space is devoted to common misconceptions. The truth is, dimensional analysis has its limitations and difficulties as well as its advantages. This paper outlines a simple and workable method which yields information similar to that obtainable by dimensional reasoning. It consists in transforming the equations of a problem, differential or otherwise, so that all the variables are dimensionless. Simple inspection then shows how these dimensionless variables are related. We shall name the method *inspectional analysis*, for this term describes it well. The essential idea of the method is briefly stated in Bridgman's book, and Norman Campbell (3) has urged its adoption on several occasions. Our present purpose is the practical one of explaining the method fully, and applying it to a simple problem in which it yields more information than dimensional analysis. Previous writers have not indicated how one can make effective use of *the physical information contained in initial conditions and boundary conditions.* (See example, Section 3.) In some cases, the method presents no advantage over dimensional analysis, but in others, it gives a clearer physical insight.

1. Discussion of Buckingham's Pi Theorem and Dimensional Constants

It will first be convenient to state certain definitions and theorems of dimensional analysis. "Fundamental quantities" are those in terms of which other physical quantities are defined. In mechanical problems, it is customary to take length, mass and time as fundamental; these quantities being denoted by L, M, and T in dimensional equations. Quantities defined in terms of the fundamental ones may be called

"derived," velocity being an illustration.[1] The basic axiom of dimensional reasoning is that the relative magnitude of two physical quantities of the same kind cannot be altered by any change of unit size. In applying this axiom, a mistake is often made by assuming that the quantity sought is a product of powers of the variables on which it depends. Thus, let us consider how the period P of a simple pendulum depends on length l, linear amplitude A, and on the acceleration of gravity. If we assume that P is given by the formula $P = kl^a g^b A^c$, the dimensional equation is $T = L^a(L/T^2)^b L^c$. To satisfy the basic axiom, the exponents of L and T must be the same in both members of this equation. Comparison shows that $b = -1/2$, and $a + c = 1/2$, but a and c cannot be separately determined. Therefore,

$$P = k(l/g)^{1/2} f(A/l)$$

where k is a pure number and f an arbitrary function of the dimensionless ratio A/l.

Sometimes the discovery of dimensionless variables on which a sought-for quantity depends causes difficulty, and it is desirable to know how many such variables to expect. The answer is supplied by the pi theorem of Buckingham (2).

Let f be the quantity for which we seek a formula, and let it depend on other quantities g, h, etc., either fundamental or derived. Then the desired relation is

$$\varphi\ (f, g, \text{etc.}) = 0. \tag{1}$$

Suppose the variables of φ are n in number, and that they may be expressed in terms of r fundamental variables x, y, etc. It is further assumed that eq. (1) is "complete," that is, all its numerical coefficients

[1] Often there is confusion as to the number of fundamental quantities which must be employed. One may feel it is unnecessary to introduce absolute temperature as a fundamental quantity, because it is proportional to the average kinetic energy of a gas molecule. The correct view is that we should use just as many fundamental quantities as the number of types of measurement-operations which must be specified before we can measure the quantities involved in our problem. In a *phenomenologic problem*, that is, one in which we neglect the atomic nature of matter, we are at liberty to introduce temperature as a fundamental quantity, thereby making it unnecessary to use lengths, masses, and times associated with individual molecules.

are dimensionless.[2] The pi theorem then states that eq. (1) can be put into the form

$$F(\pi_1, \pi_2, \ldots\ldots) = 0, \tag{2}$$

where the π's are dimensionless in all the fundamental variables, and are $n-r$ in number. Often it is convenient to solve eq. (2) for the quantity f, which must be contained in one or more of the π's. If it happens that f appears only in one of the π's, say π_1, which may be of the form fg^ah^b, we have

$$f = \frac{1}{g^a h^b} D(\pi_2, \cdots \pi_{n-r}) \tag{3}$$

where D is an arbitrary function of its variables.

In setting up eq. (1), we are usually obliged to include a number of dimensional constants among the quantities f, g, etc. *A dimensional constant is one whose numerical value can be changed by altering one or more of the fundamental units.* The gravity constant g in the pendulum problem is an example. In any practical problem, we employ as few dimensional constants as possible, for they count as additional variables in the function φ whose properties we wish to investigate. It may even happen that the number of dimensional constants, q, is so large that $n+q-r$ is larger than n; if so, the number of dimensionless variables in eq. (2) is larger than the original number of variables n, and we may not gain any advantage by throwing our equation into the form (2) or (3). This difficulty is all the more likely to occur because of the fact that when we write out our list of variables, we try not to leave out any variable, being certain that if we do, we shall not obtain a correct result. Suppose, for example, we desire to find the drag per unit length of an airplane wing. This may depend on the cross-sectional dimensions of the wing, on the pressure and density of the air, and on the velocity of the plane. The question now arises whether the velocity of sound should be included in our list. We feel intuitively that it will be convenient to have this velocity in our result, even though it depends only on the pressure and density of the air and on the ratio of the specific heats at constant pressure and at constant volume.

[2] For example, if a falling body starting from rest moves a distance s in time t, the equation $s = 1/2\, gt^2$ is complete, but the equation $s = 16\, t^2$ which holds in the English system of units is not complete, because the coefficient 16 is dimensional.

As a matter of fact, correct results are obtained by including the velocity of sound in the list of dimensional constants and variables. The frequent occurrence of questions like this shows that we need a general method for finding the dimensional constants and variables which enter into the problem. This is supplied in the following section.

2. PRINCIPLES OF INSPECTIONAL ANALYSIS

When we write down the differential equations and boundary or initial conditions of our problem, or of some problem of the same type characterized by simpler geometrical and kinematic conditions, then the variables can always be replaced by dimensionless ones. When this has been done, a formal solution of the equations may be obtained by writing each dependent dimensionless variable as a power series (or some other series capable of representing an arbitrary function), in which the arguments are the independent dimensionless variables. To understand the connection of these variables we do not have to carry through the series solution; we only need to perceive that *the dimensionless variables and combinations of dimensional constants which occur in the final integrated form of the equations are exactly those occurring in the original differential equation and the boundary or initial conditions.*

3. AN EXAMPLE: VIBRATIONS OF A STRETCHED WIRE

Let us illustrate the inspectional method by discussing a very familiar problem. We have a standing sine wave on a stretched wire which lies along the x-axis between the points $x = 0$ and $x = L$, when at rest. Let the mass per unit length be D and the tension T and let y be the transverse displacement of the wire at any point x, at any time t. The differential equation is

$$\frac{\partial^2 y}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2}, \tag{4}$$

where v is the velocity of waves on the wire, namely, $(T/D)^{\frac{1}{2}}$. To be definite, we shall suppose the initial conditions are:

$$y = A \sin \frac{\pi x}{L} \text{ when } t = 0; \tag{5}$$

$$\frac{\partial y}{\partial t} = 0 \text{ when } t = 0. \tag{6}$$

A is the arbitrary amplitude of vibration. The solution satisfying (4), (5), and (6) is easily obtained, but our present purpose is to get as much information as we can without solving the differential equation. Since equation (5) is linear, y must be proportional to A, so it is logical to employ the dimensionless quantity y/A as a dependent variable. Equation (5) suggests x/L as another convenient variable. Multiplying both sides of equation (4) by L^2/A,

$$\frac{\partial^2\left(\frac{y}{A}\right)}{\partial\left(\frac{vt}{L}\right)^2} = \frac{\partial^2\left(\frac{y}{A}\right)}{\partial\left(\frac{x}{L}\right)^2}, \tag{4'}$$

and the solution must be

$$y/A = f(x/L, vt/L), \tag{7}$$

where f is an arbitrary function and may contain any number of dimensionless constants. Putting $t = 0$, we see that (5) and (6) are satisfied. This concludes the inspectional analysis, but the problem is now in such simple form that we can get further information. The form of (5) suggests that we write y/A as a double Fourier series with undetermined coefficients:

$$y/A = \sum_m \sum_n C_{mn} \sin(m\pi x/L) \cos(n\pi vt/L) + \text{etc.} \tag{8}$$

Then it is easy to see that only the term $A \sin \pi x/L \cos \pi vt/L$, satisfies all the conditions of the problem.

Let us now study the problem by dimensional analysis. Equation (1) takes the form,

$$\varphi(y, x, t, T, D, A, L) = 0. \tag{1'}$$

The fundamental variables are length, mass and time, so the number of dimensionless variables must be 7 minus 3 or 4. Since we employed (5) and (6) in the inspectional analysis, it is only fair to give the dimensional analyst corresponding grist for his mill. We tell him, "When $t = 0$, y/A is a function only of x/L; and $\partial y/\partial t$ is zero." His problem is to seek four independent dimensionless quantities. After reflection, he suggests that

$$y/A = F(x/L, A/L, vt/L),$$

whereas, the previous treatment showed clearly that A/L does not occur in the solution. The reader may say, "It is not surprising that one can get more out of qualitative study of the differential equation than out of mere dimensions." I agree; it is not surprising.

4. DISCUSSION

Let us now compare dimensional analysis and inspectional analysis. Both have their strengths and weaknesses. Dimensional analysis is rapid, and, in simple problems, aided by the physical common sense of the user, it often yields all the information we want. Inspectional analysis is certainly capable of yielding all the information which can be obtained by dimensional analysis, and it may yield more. In most problems, the dimensional constants may be divided into two classes: (1) those which enter into the general differential equations, and, (2) those which enter into the initial and boundary conditions, and so pertain only to the problem in hand. In using the method of inspection, we can see automatically in which class a given constant belongs. In problems which can be treated by kinetic methods, the inspectional method guards us against writing down too many dimensional constants (such as the mass of a molecule, or its radius); this may occur in using dimensional analysis because of mental fluctuations between the molecular and large-scale points of view.

Finally, dimensional analysis furnishes no way by which we may see where the difficulty lies if we make a mistake or arrive at an absurd result. In using the inspectional analysis, we are always in a position to employ straightforward physical arguments. Automatically, it shows us where we lack information. We can, for example, see clearly whether we have knowledge of all the boundary and initial conditions necessary to make our problem definite. Often a difficulty can be removed if we can only formulate it clearly.

To summarize, inspectional analysis really consists in taking the first steps toward the actual solution of a problem, and the essential points are: (1) that in taking these steps we can automatically and systematically obtain all the information supplied by dimensional analysis, and, (2) that very often additional useful information is obtained.

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THE CHEMICAL COMPOSITION OF THE CHINA BERRY (MELIA AZEDARACH)

By R. W. Bost and Dan Fore, Jr.

Chemical data on *Melia Azedarach* are meager in spite of the fact that the tree has been known for centuries. Extracts have been made of the bark, seeds, and leaves almost since the dawn of history and have been used as a panacea for many ills in various parts of the world. A few of these are mentioned herein.

In 1830 Barton mentioned *Melia Azedarach* as being the most active anthelmintic known at that time. The dried berries in spirits were employed against ascarides, tapeworm, and verminous maladies in general (11). The pulp of the berry boiled in lard has been used as an ointment in treating scalded scalps (11), while the pulp mixed with tallow has been used as an "antisporic" in the case of tinea capitis (2). The berry has also been used in the treatment of catarrh (12), in the eradication of moths (11) and in the preparation of soap. In some cases the leaves of the tree have been used as a pot herb (5) while in other cases decocted leaves have served as an astringent and stomachic as well as in the treatment of hysteria (11). Symptoms of giddiness, faintness, dimness of sight, mental confusion, and vomiting have been observed after ingestion of the sap of the tree (9). Birds, after eating the berries, show symptoms of intoxication and partial paralysis. The berries have been reported to be efficacious in the treatment of horses for "bots" (11). Through the center of the stone-like seed a hole is easily made, hence they are strung into beads which may be easily dyed any desirable color. Wherever the tree grows, it becomes known for its many berries, its blossoming odor, or some special use.

It has been reported that *Melia Azadirachta*, a kindred plant, contains margosin which is an anti-protozoal (4). This substance has been used in treating suppurating scrophulus glands and leprosy.

In view of the multiplicity of uses which have been reported of *Melia Azedarach* and its physiological effects on various organisms, it seemed desirable to make a study of the chemical composition of the fruit. Since *Melia Azadirachta* has been used in treating leprosy it was thought

that *Melia Azedarach* might also contain some anti-leprosy constituent such as chaulmoogric or hydnocarpic acids or their esters.

Since certain marked physiological symptoms have been reported after ingestion of different parts of the tree, and since the berry contains 1.5 per cent nitrogen, it seemed probable that some of the common alkaloids might also be present. Aqueous solutions of the berry give strong reduction tests with Fehling's and similar solutions. The berry also gives various protein tests. The tests for alkaloids, carbohydrates, and proteins are given below together with the results.

In this paper are described the extraction of the oil, its physical and chemical properties, and the resolution and percentage of its constituents.

EXTRACTION OF OIL

1. Acetone as Solvent

The ripe berries of *Melia Azedarach* were collected, dried two months, stemmed and the faulty fruit removed and ground to a coarse meal in a burr mill. This material was extracted by shaking with acetone at room temperature in a shaking machine for four hours. The solvent was filtered, the residue washed with cold acetone, air-dryed for twelve hours, re-ground to as fine a meal as possible and extracted as before. Evaporation of the acetone was done in a continuous apparatus so arranged that the main body of the solvent dripped slowly into a distillation flask. The flask was heated on a water bath at fifty degrees and the removal of the solvent took place under diminished pressure in an atmosphere of nitrogen. The residue thus obtained contained the oleaginous material together with water, small amounts of carbohydrate and other materials. This residue was extracted with ether, the ethereal extract dried over anhydrous sodium sulfate and the extract finally evaporated as was the acetone solution. The oily material remaining in the flask is referred to in this work as whole oil. The whole oil was mixed with five volumes of petroleum ether whereupon a flocculent material which settled out was filtered off. This material was reserved for further work. The petroleum ether was removed similarly to the acetone and ether. After all the solvent had distilled, the temperature was raised to 90° and the oil treated with a rapid stream of nitrogen under reduced pressure. From 2882 g. of berries, 168.2 g. (5.83 per cent) oil was obtained.

The constants determined for the whole oil and fatty material are given in Table I.

2. Petroleum Ether as Solvent

Berries prepared as described above were extracted with petroleum ether (B.P. 50°–80°) in a large Soxhlet extractor for six hours. The petroleum ether extract was then transferred to a tared flask and the solvent distilled. The oil thus obtained differed markedly in color and consistency from the acetone-extracted oil. Where the acetone-extracted oil is bright yellow, containing flocks of fat, and quite fluid, the oil from the petroleum ether-extract is reddish brown in color, viscous at room temperature and completely solidifies in an ice bath. The iodine number of this oil is 126 and the saponification value is 193.3.

TABLE I

Oil from Melia Azedarach

	WHOLE OIL	FATTY MATERIAL
Specific Gravity @ 25°	0.9182	
Refractive Index @ 15°	1.4766	
Saponification Value	191.9	194.1
Iodine Number (Hanus)	135.4	104.0
Acid Value	3.62	
Non-Saponifiable Matter	1.6%	

3. Separation of Non-Saponifiable Material

Qualitative tests showed that the oil contained glyceryl esters of both saturated and unsaturated acids.

One hundred and sixty-six grams of pure acetone-extracted oil were saponified by boiling two hours with 750 cc. of approximately 2 N KOH. The excess alcohol was distilled off, and the non-saponified material extracted by the method of Jamieson (7). The residual alcohol-soap solution was taken up in 250 cc. of ether, and thoroughly shaken with 1200 cc. of aqueous KOH (11.2 gms. base per liter), three times with 500 cc. portions, and ten times with 100 cc. portions, care being taken not to withdraw any emulsion which was formed. The ethereal solution was washed with water until it was no longer alkaline to phenolphthalein. This extract, on evaporation, yielded 2 7 gms. (1.6 per cent) of non-saponifiable matter. This material was recrystallized from alcohol and finally pentane. It consisted of colorless crystals which began to soften at 120° and melted completely at 180°. It gave a negative Leibermann-Buchard test. Other tests indicated the sub-

stance was a mixture of aromatic hydrocarbons. Since only a small amount of the material was available, identification of the hydrocarbons composing the mixture was not attempted.

4. Separation of the Acids

From the soap layer, after the separation of the non-saponifiable fraction, the fatty acids were obtained by acidification with HNO_3 and extraction with petroleum ether. The HNO_3 for this purpose was prepared by mixing one volume of pure concentrated acid with two volumes of distilled water and then boiled to expel the oxides of nitrogen. The acid was not used until the cold solution failed to give a positive test for NO_2 with starch-potassium iodide paper, since the oleic acid is converted into elaidic acid by the oxides of nitrogen. The liberated fatty acids were extracted with ether and the latter evaporated to secure the free fatty acids. The acids thus obtained had a mean molecular weight of 185. These were then dissolved in ten times their weight of boiling 95 per cent alcohol to which was added a one-half mole excess of lead acetate in an equal volume of hot alcohol. The solution was cooled to room temperature and placed in a bath at 15° for 24 hours to insure complete precipitation. The precipitate was filtered, washed several times with cold 95 per cent alcohol, then dissolved in 95 per cent hot alcohol, a few drops of glacial acetic acid added and the solution cooled as before. After filtering and washing, the filtrates from the two precipitations were combined and reserved for future use.

5. The Saturated Fraction

The precipitated lead soaps were suspended in ether, decomposed by shaking with dilute nitric acid, the acidulated lead nitrate solution drawn off in a separatory funnel, and the ethereal solution washed with water until neutral with methyl red. Evaporation of the ether extract gave a solid cake, light yellow color, consisting chiefly of a mixture of the saturated acids.

6. The Unsaturated Fraction

The alcoholic solution of the unsaturated lead soaps obtained from the separation of the saturated members in (4) was evaporated to a low volume and dilute HNO_3 added in slight excess to decompose the salts and water added to take the lead salts into solution. The freed fatty acids were extracted with ether, the latter washed with water to remove the mineral acid, the solvent evaporated, and the last traces of water

removed from the liquid unsaturated acids by bubbling a stream of nitrogen through while heating under reduced pressure on a water bath at 90°. The absence of linolenic acid was proved by the Hexabromide Method (6). The weights of saturated and unsaturated acids and the percentages of each are given in Table II.

7. *Esterification of the Acids*

The acids from the saturated and unsaturated fractions were dissolved in one and one-half times their weight of methyl alcohol containing 3.5 per cent HCl by volume. Twenty-five per cent of the fatty acid weight of freshly fused $CaCl_2$ was added and the mixture refluxed 20

TABLE II

Acids

	WEIGHT	PER CENT
	gms.	
Saturated Acids (210 grams oil)	24.05	11.45
Unsaturated Acids (210 grams oil)	185.70	88.43

TABLE III

Methyl Esters

	ACID USED	ESTER	PER CENT YIELD
	gms.	*gms.*	
Saturated Acids	20.0	20.5	90.7
Unsaturated Acids	170.0	172.0	97.3

hours. The esters were then separated by means of ether, washed to remove alcohol and mineral acid, and then washed four times with sodium carbonate (8 grams per liter) to remove unreacted fatty acid. The alkali was removed by water, the ether solution dried over anhydrous sodium sulfate, and evaporated in an atmosphere of nitrogen. The residue was dried under diminished pressure in a stream of nitrogen for six hours at 90°.

8. *Fractionation of Methyl Esters*

The methyl esters of the saturated and unsaturated acids were fractionated in an atmosphere of nitrogen at a constant pressure of 5 mm. The weights of the fractions obtained are given in Table III and the distillation temperatures are given in Tables IV and V. The iodine

numbers and saponification value of each final fraction are also given. Since the esters of the unsaturated acids are not readily separable by fractional distillation, the percentage of these constituents present was

TABLE IV

Analysis of Saturated Esters

B.P. OF FRACTION (5 MM.)	SAPONIFICATION VALUE	MEAN MOLECULAR WEIGHT	PER CENT METHYL PALMITATE	PER CENT METHYL STEARATE
175–9°	205.66	272.81	90.23	9.77
182–7°	198.00	283.35	51.09	48.91
Residue	189.10	296.70	5.50	94.50

Total weight of Methyl Palmitate	10.93 g.
Total weight of Methyl Stearate	8.57 g.
Per cent of Palmitic Acid	55.95
Per cent of Stearic Acid	44.05

TABLE V

Analysis of Unsaturated Esters

B.P. OF FRACTION (5 MM.)	SAPONIFICATION VALUE	IODINE NUMBER	WEIGHT
			gms.
188–90°	190.2	132.90	98.4
190	190.0	147.63	25.6
191	192.7	150.15	29.5
198	.....	133.06	4.3
Residue	.....	141.23	5.3

TABLE VI

Analysis of Whole Fatty Acid Mixture

Iodine Number	131.28
Thiocyanogen Number	82.88
Saturated Acids	11.45%
Palmitic	55.95%
Stearic	44.05%
Unsaturated Acids	88.43%
Oleic	41.81%
Linoleic	58.18%

determined by the thiocyanometric method of Kaufman (8). From the thiocyanogen and iodine values of the acids, simultaneous equations may be set up, the solution of which will give the percentage composition of the fatty acid mixture as indicated in Table VI.

OTHER CONSTITUENTS OF MELIA AZEDARACH

Tests for Alkaloids and Poisonous Substances

It has been observed that birds after eating the fruit of *Melia Azedarach* develop toxic symptoms marked by partial paralysis of the whole body and total loss of control of the wings. The latter drag limply as the intoxicated bird walks. This stage passes gradually into a period of insensibility followed usually by death. Morrison and Grant (10) found that the ground meal of the berries produced symptoms in cattle marked by incapacitation of the fore limbs. Picrotoxin, an active plant principle, causes selective paralysis of the fore limbs (3).

Five hundred grams of ground berries were extracted with 1500 cc. of hot water. To this solution was added 50 g. of magnesium oxide to precipitate the tannins and acidic substances, and the filtrate was evaporated to a syrup which was treated with five times its volume of hot alcohol. The alcohol extracts were combined, filtered, and evaporated. The residue was shaken with hot water and the solution filtered, acidified with dilute H_2SO_4, and extracted repeatedly with chloroform. The latter extract, on evaporation, yielded a small brownish bitter residue which failed to give any of the characteristic tests for picrotoxin. When dissolved in water and injected into the lymph sac of a healthy frog it did not show the symptoms of picrotoxin poisoning which were observed in a control poisoned with a known sample of picrotoxin.

Another attempt was made to isolate picrotoxin using the Stas-Otto Method (1). The various extracts when evaporated left a small brownish residue, none of which responded to picrotoxin tests. Negative tests were also obtained for the alkaloids listed in Autenreith and Warren (1).

It is believed that picrotoxin is absent in *Melia Azedarach* and that some unknown alkaloid of high toxicity occurs in traces, since only a small amount of this substance was obtained. There is also the possibility of the poisonous substance existing as the glucoside.

Carbohydrates

When an acetone extract of the ground berries is allowed to evaporate spontaneously, two layers will eventually form: a yellow oily layer which separates to the bottom and which has already been described and a top layer which is reddish in appearance. This layer was evaporated to remove the acetone and extracted with hot absolute alcohol. The latter solution was concentrated, cooled, and anhydrous ether added

in sufficient volume to precipitate the saccharide. Upon filtration, a white hygroscopic powder was obtained which gave positive Fehling's, Benedict's, and Barford's tests. It gave negative Phloroglucinol, Seliwanoff, Ammonium Molybdate, and Methyl Phenylhydrazine tests. It also gave a phenylhydrazone which melted at 205.5°. The sugar was shown to be glucose. No other carbohydrate was found.

Proteins

From an aqueous extract of the berries, proteins may be precipitated by half and full saturation with ammonium sulfate. The precipitates so obtained give positive Xanthoproteic, Millon's, Biuret and Hopkins-Cole tests for proteins. The latter test was not as heavy as the others. The protein material needs further study for final classification. It is of interest to note that the presence of one or more of the few vegetable albumins which are precipitated at half saturation with ammonium sulfate is possible.

Discussion of Results

The oil of the fruit of *Melia Azedarach* may be classed as a semi-drying oil. It occurs in too small a percentage (5.83 per cent) to be of any commercial importance at present. The oil consists of 11.45 per cent of saturated acids of which 55.95 per cent is palmitic acid and 44.05 per cent is stearic acid. The unsaturated acids occur in the oil to the extent of 88.43 per cent of which 58.18 per cent is linoleic and 41.81 per cent is oleic acid. The authors were unable to detect the presence of chaulmoogric or hydnocarpic acids. If the oil contains an anti-leprosy material it must be of some other nature than the aforementioned acids. No substance was found which is known to give the physiological reactions reported in the literature. Further studies on the physiological effects of the non-saponifiable fraction are being investigated. The presence of glucose in the berry has been shown which explains the behavior of aqueous solutions of the berry with reducing solutions as well as the fermentation of the aqueous solutions. Further work is necessary to definitely classify the proteins.

SUMMARY

1. The fruit of *Melia Azedarach* has been studied and found to contain a semi-drying oil, glucose, a non-saponifiable constituent consisting chiefly of hydrocarbons, certain proteins, and a poisonous constituent of unknown constitution.

2. The oil consists chiefly of the glycerides of palmitic, oleic, linoleic, and stearic acids. No linolenic, chaulmoogric, or hydnocarpic acids were detected.

3. The oil was extracted with various solvents and a case of selective extraction was noted.

4. Picrotoxin was shown to be absent.

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SOLUBILITY STUDIES IN THE SYSTEMS: BENZENE-p-NITROTOLUENE AND BENZENE-o-NITROTOLUENE

By H. D. Crockford and E. C. Powell, Jr.

The purpose of the work reported in this paper was to determine the temperature-composition diagrams for the binary systems: benzene-p-nitrotoluene and benzene-o-nitrotoluene. These data show if compounds of either a stable or unstable nature are formed between the pairs and whether the solutions involved are ideal in nature. From the data may be calculated the latent heat of fusion of the components. This work is a continuation of a series of investigations on the thermal properties of the nitrotoluenes which have been carried on in the Chemistry Laboratory of the University of North Carolina.

The nitrotoluenes used were the highest grade of Eastman product. The o-nitrotoluene was further purified by recrystallization from hot carbon tetrachloride and the p-nitrotoluene by recrystallization from its own melt. The benzene used was the Kahlbaum "zur Analysis" grade. It was found to be extremely pure. Constant melting points were found as follows: p-nitrotoluene, 51.4°; o-nitrotoluene, −10.4°; and benzene, 5.42°C.

The same general method of procedure as has been employed in previous investigations (Crockford and Simmons, Journ. E. M. Sci. Soc. **42**: 273. 1933) was used. Mixtures were prepared as shown in Table I so as to secure sufficient data for the systems. These mixtures were made by weighing the p-nitrotoluene in the usual way, by weighing the o-nitrotoluene in a weighing burette, and by measuring the benzene from a regular pipette and then calculating its weight from the density at the given temperature. Cooling curves were then obtained from the various mixtures and the freezing and eutectic points obtained by the method of Bell and Herty, as discussed in the reference cited.

Due to the low temperatures encountered in most of the mixtures some modification of the apparatus was necessary. A vacuum bottle of one quart capacity was used as an outside vessel. Into the mouth was fitted a cork stopper through which was inserted an eight inch test tube which contained the mixture being studied. The stopper of this test

tube contained openings for the thermometer and the loop stirrer. The cooling mixture employed in the vacuum bottle for the lower temperatures consisted of ethyl ether and solid carbon dioxide. An opening in

TABLE I

SOLVENT	MOL FRACTION SOLVENT	log x	FREEZING POINT	$\frac{1}{T} \times 1000$
Benzene-p-Nitrotoluene System				
			°C.	
p-Nitrotoluene	1.000	.000	51.4	3.083
	.948	−.023	48.8	3.108
	.856	−.067	43.9	3.156
	.697	−.157	34.2	3.255
	.548	−.262	23.3	3.375
	.394	−.404	11.2	3.519
	.305	−.516	2.8	3.626
	.2500	−.602	−2.9	3.703
Benzene	.789	−.103	−7.2	3.762
	.798	−.098	−6.8	3.757
	.835	−.078	−4.1	3.719
	.900	−.046	−0.4	3.669
	.939	.027	+2.0	3.632
	1.000	.000	5.4	3.592
Benzene-o-Nitrotoluene System				
o-Nitrotoluene	1.000	.000	−10.4	3.808
	.869	−.061	−16.7	3.902
	.752	−.124	−23.3	4.005
	.663	−.179	−28.6	4.092
	.594	−.226	−32.4	4.162
Benzene	.475	−.323	−29.9	4.114
	.550	−.260	−25.0	4.032
	.700	−.155	−14.1	3.862
	.800	−.097	−7.2	3.762
	.908	−.042	−0.3	3.667
	1.000	.000	+5.4	3.592

the cork of the vacuum bottle allowed the carbon dioxide gas to escape. These cooling mixtures were held a few degrees below the freezing points of the various melts. In some cases "seeding" had to be employed to prevent excessive supercooling. In some of the low temperatures ice

was formed in the melt from the moisture in the air of the test tube. This trouble was partially overcome by passing dry nitrogen gas into the tube.

For the higher temperatures mercury thermometers were employed. For the lower temperatures it was necessary to use pentane thermometers. All thermometers were properly calibrated.

In Table I are given the data for the compositions and freezing points of the various mixtures. The table also includes the log x (x = mol fraction of solvent) and the $1/T \times 1000$ values. Temperature-composition diagrams are not included in the paper as the systems prove to be simple in nature and include only one eutectic each. The log $x - 1/T \times 1000$ plots are nearly straight lines departing from the linear only in the more concentrated solutions. The temperature readings are corrected for stem exposure. It is to be noted that in Table I the freezing points are given in degrees Centigrade while the $1/T \times 1000$ values are calculated in degrees Absolute. For the p-nitrotoluene system temperatures are accurate to .1°. For the o-nitrotoluene system they are reported to the same value but they are hardly as accurate, due to the very large stem corrections which had to be applied. In some cases this correction amounted to as much as 5°C.

The systems show no indications of compound formation and on the whole are fairly ideal in nature. The eutectic temperatures were checked on a number of melts. The values are as follows: for the p-nitrotoluene system, −7.2°; for the o-nitrotoluene system, −33.3°C.

The latent heats of fusion have been calculated by means of the equation

$$\log x = \frac{L}{2.3\,R}\left(\frac{1}{T} - \frac{1}{T_0}\right) \qquad (1)$$

in which x is the mol fraction of solvent in the mixture of freezing point, T. T_0 is the freezing point of the pure solvent, R is the gas constant, and L the molal heat of fusion of the solvent. For the o-nitrotoluene the value of the molal heat of fusion is 2895 ∓ 25 calories. For the p-nitrotoluene it is 4150 ∓ 50 calories. No calorimetric values are available for comparison with the above. The values for benzene as calculated are: for the o-nitrotoluene system, 2475 calories; for the p-nitrotoluene system, 2750 calories. These are accurate to four per cent. The accepted value is 2365 calories at 15°C. In deriving equation (1) it is to be noted that L was considered constant in the integration of the equation from which (1) was derived. This is probably not

true. Moreover it is to be noted that the data in these two systems from which the L value for benzene is calculated extend over such a small temperature range that the use of the equation is questionable.

SUMMARY

1. Temperature-composition data have been obtained for the systems: benzene-p-nitrotoluene and benzene-o-nitrotoluene. The systems show no evidence of compound formation.

2. From the data have been calculated the latent heats of fusion of the components.

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THE DETERMINATION OF ALANINE IN BIOLOGICAL MATERIALS

By E. W. McChesney

A survey of the literature would lead one to the conclusion that methods for the determination of alanine in biological materials are rather thoroughly worked out. Kendall and Friedemann (1930) have published a method for the determination of alanine in such materials as culture media, peptone solutions, meat extracts, etc., based on its conversion to lactic acid by means of nitrous acid, followed by oxidation of the lactic acid to acetaldehyde according to their rather well-known technique (Friedemann and Kendall, 1929). They reported nearly quantitative conversion of alanine to lactic acid inasmuch as 97–98 percent of the theoretical amount of acetaldehyde could be obtained as a result of these two steps. Furth, Scholl, and Herrmann (1932) have applied this method to the determination of alanine in protein hydrolysates and have reported on the alanine content of a number of proteins.

It is the experience of the author and others (Furth *et al.*, 1932, and Jukes in personal communication), however, that the method of Kendall and Friedemann falls far short of what is claimed for it. With the most cautious application of their procedure, the yield of acetaldehyde is but 90–92 percent of the theoretical, the latter figure being the best ever obtained in a long series of tests. This is about 7 percent less than the amount claimed and is a serious error if one wishes to estimate alanine accurately. This would seem to indicate that the data of Kendall and Friedemann are incorrect or that there is some complication in the method which they did not encounter.

The author has made a serious attempt to improve upon the method of Kendall and Friedemann by altering such factors in the reaction as volume, time, temperature, concentration of nitrous acid, nature of the acid used to convert sodium nitrite to nitrous acid, etc. Several of these modifications give results as good as the original and are much less laborious, but none give better results. For example, in the deamination process, 5 cc. of 10 percent acetic acid may be substituted for the concentrated HCl or sodium bisulfate recommended in the original

procedure. With this change it is necessary to shake the reaction vessel only occasionally instead of continuously during the half-hour period in the boiling water bath; results averaging 91 percent yield may be obtained even more consistently than with Kendall and Friedemann's procedure. It would appear that an equilibrium is reached at the point of 91 percent yield and no method has been found which would serve to shift it further in the desired direction. Some attempt has been made to identify the product (or products) composing the remaining 8 or 9 percent but other than the fact that it does not seem to be pyruvic acid, no definite statement can be made at this time.

In applying this technique to biological materials, it must be remembered that all of the nineteen or twenty amino acids serve as potential sources of volatile aldehydes according to the equations:

$$R{-}\underset{\displaystyle NH_2}{\overset{\displaystyle H}{C}}{-}COOH + HNO_2 \rightarrow R{-}\underset{\displaystyle OH}{\overset{\displaystyle H}{C}}{-}COOH + N_2 + H_2O$$

$$R{-}\overset{\displaystyle H}{\underset{\displaystyle OH}{C}}{-}COOH + O \rightarrow RCHO + CO_2 + H_2O$$

A few of the amino acids such as glutamic acid, glycine, proline, serine, arginine, and hydroxyproline yield no trace of volatile aldehyde, according to Furth *et al.* and the writer's own observations. However, even phenylacetaldehyde, b.p. 194°C., from phenylalanine, comes over to a slight extent under the conditions of the experiment and would appear in the calculations as alanine. Kendall and Friedemann have usually assumed that these higher-boiling aldehydes would be held back by the reflux condenser. Some of the interfering compounds derived from the other twelve or thirteen amino acids[1] may be removed preliminary to oxidation by precipitation as the lead salts of the hydroxy acids (McChesney, 1934), but others such as valine, leucine, isoleucine, etc., give much trouble. Furth and co-workers attempted to get around the difficulty presented by these compounds by a careful fractional distillation of the aldehydes, seeking to hold back those boiling at temperatures higher than acetaldehyde. (Isobutyraldehyde, b.p. 63°C., from valine, is the nearest to acetaldehyde, b.p. 21°C.: the problem is obviously not a simple one.)

[1] Notably cystine, phenylalanine, tyrosine, lysine, histidine, and aspartic acid. For outline of method see McChesney (1934).

The results obtained with this method in the hands of other workers (Jukes, personal communication) have not been encouraging, however, and it would seem advisable to remember in applying the original method for alanine, at least, that many substances are reacting to some extent and will affect the values obtained.

The work of Furth, Scholl, and Herrmann is worthy of some detailed comment. They have used Kendall and Friedemann's technique for the determination of alanine in protein hydrolysates freed from the diamino and dicarboxylic acids. They report determinations on amounts of solution representing 0.8 to 16 mg. of protein. In the case of silk fibroin, which contains about as much alanine as any protein (25 percent), this would represent 0.2 to 4 mg. of alanine in the solution analyzed and would require for the final titration 0.45 to 9 cc. of 0.01 N iodine solution, while a blank usually requires about 0.15 cc. of the same. These results seem reasonable, at least when quantities of 4 mg. of alanine are being determined, but most of their determinations were made on quantities of protein smaller than 5 mg. and with proteins containing much less than 25 percent of alanine. In fact, some of their determinations would have required as little as 0.2 cc. of 0.01 N iodine, hardly more than a blank. In the experience of the author quantities of alanine less than 2 mg. (requiring 4.5 cc. of 0.01 N iodine) cannot be determined with any degree of accuracy[2] even when the fractional distillation step is omitted, and it hardly seems possible that determinations accurate within several hundred percent could have been made on such minute amounts of material when one considers the difficulty of the manipulations involved. The authors have not suggested any reason for using these very small quantities. The work of Jukes (1933) in this connection is of significance. He attempted to use the method of Furth and co-workers for the determination of alanine in livetin and says (personal communication) that by the time pure solutions of alanine were carried through the deamination, oxidation, and fractional distillation procedures only about 70 percent of the alanine could be accounted for, even when the fractional distillation was carried on for a much longer time than directed. The paper of Furth *et al.* also records results obtained when known amounts of alanine were added to the protein solutions under examination and reports recovery averaging 92 percent. Recalculation of the results shows, however, that the recovery really averaged 90 percent and was therefore in many cases less.

[2] This was also the experience of Kendall and Friedemann.

In the light of these facts, it would appear that the work on the determination of alanine needs considerable revision. The first requisite for significant progress is a method which will convert alanine quantitatively to lactic acid. If none can be found it must become generally recognized that a correction factor of 9 percent is to be applied to the results.

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THE STOMATOPODS (MANTIS SHRIMPS) OF THE CAROLINAS

By G. Robert Lunz, Jr.

Figures 1–6

An examination of the literature pertaining to the mantis shrimps shows that prior to the present one, three lists[1] of stomatopods have been published for the Carolinas. In 1848, Gibbes appended a faunal list to Toumey's Report on the Geology of South Carolina. In this list four species were recorded. In 1878, Coues and Yarrow in their Fort Macon Fauna Report list a single species. In 1883, L. O. Howard compiled a hypothetical list of the Invertebrate Fauna of South Carolina and listed five species. Since 1883 several changes have been made in the classification of the stomatopods, a new genus has been added to those recorded for the two states, ranges have been extended, and records of rare species have been substantiated. This leads me to believe that a new list for the Carolinas will be of value

The present list is based on the material to be found in the collection of the Charleston Museum at Charleston, S. C.; the U. S. Bureau of Fisheries Biological Station at Beaufort, N. C.; the University of North Carolina at Chapel Hill, N. C.; and the North Carolina State Museum at Raleigh, N. C. In addition to studying the above mentioned material, I have been allowed to examine the records and many of the specimens in the U. S. National Museum.

I wish to express my gratitude to the authorities at the U. S. National Museum for the privilege of examining their collection. Also, I am duly grateful to the Bureau of Fisheries for the courtesies extended me at its Biological Station at Beaufort, N. C. It is a privilege to be able to acknowledge the help of Dr. Waldo L. Schmitt of the U. S. National Museum. I am also grateful to Dr. H. V. Wilson of the University of North Carolina, Dr. H. H. Brimley of the N. C. State Museum, Mr. Paul

[1] I omit specific mention of Bigelow (1894), Brooks (1886), Gibbes (1850), and Kingsley (1878) not because of a lack of appreciation of the value of their work but because either they did not publish a list of stomatopods or because their lists do not deal solely with North or South Carolina species.

R. Weidner of the College of Charleston, and Mr. E. Burnham Chamberlain of the Charleston Museum.

The stomatopods are represented in the Carolinas by 6 species, distributed through 3 genera, as follows: *Gonodactylus*, 1; *Lysiosquilla*, 2; and *Chloridella*, 3. In the earlier records the mantis shrimps of the genus *Chloridella* were called *Squilla*. This name is no longer in good standing (see Rathbun, 1902, p. 54, foot note) though often used nowadays to refer to the stomatopods in a general way.

The key which follows is based on a few simple characters and will serve to differentiate the genera. This key, however, is devised to apply only to those stomatopods recorded for North and South Carolina.

KEY TO GENERA OF STOMATOPODS IN NORTH AND SOUTH CAROLINA

A¹ Raptorial claw dilated at base; dactylus without teeth; eyes dilated. *Gonodactylus.*

A² Raptorial claw not dilated at base; dactylus bearing 5 or more teeth.

B¹ Dactylus with 9 or more teeth..... *Lysiosquilla.*
B² Dactylus with 5 or 6 teeth..... *Chloridella.*

Gonodactylus oerstedii Hansen

Gonodactylus oerstedii Hansen, Isopoden, Cumaceen und Stomatopoden, Ergeb. d. Plankton. Exped. II (1895), p. 65, foot note.

Diagnostic characters: A *Gonodactylus*, the dactylus of the raptorial claw of which bears no spines and is dilated at the base. The posterior portion of the body is decidedly convex and strongly built. The rostrum bears an acute spine which is about one-half the width of the entire rostrum. The dorsal surface of the telson is not spiny. The first exposed thoracic segment has no lateral process. The eyes are cylindrical.

Remarks: The Charleston Museum has in its collection a dried specimen presumably taken off Charleston Harbor. This specimen formed a part of the L. R. Gibbes Collection. A catalogue card states that a specimen of this species was in the Gibbes Collection and that it was collected in South Carolina. It is probable that the specimen under discussion is the one mentioned on the catalogue card. The National Museum has a specimen from Cape Fear, N. C. It also has a much-mangled specimen taken off Charleston Harbor, which is doubtfully determined as this species. There are two specimens at the Bureau of Fisheries Biological Station at Beaufort, N. C. These specimens were taken by the "Fish Hawk" off Beaufort, N. C., May,

1907. (I have not been able to differentiate the few specimens I have examined into varieties as described by Dr. Schmitt, 1919, p. 96.)

It is evident that this species is not common in the Carolinas. It is known to occur southward from North Carolina and Bermuda to Brazil, including the Bahamas, the West Indies, and the Gulf of Mexico. It is also recorded from the Gulf of California.

The genus *Lysiosquilla* is represented in North and South Carolina by two species.

KEY TO THE SPECIES OF LYSIOSQUILLA IN NORTH AND SOUTH CAROLINA

A¹ Dactylus of raptorial claw with more than 10 teeth, eyes cylindrical with hemispherical cornea ..... *excavatrix* Brooks

A² Dactylus of raptorial claw with 9 or 10 teeth, eyes T-shaped with bilobed cornea ..... *scabricauda* Lamarck

Lysiosquilla excavatrix Brooks

Lysiosquilla (*Coronis*) *excavatrix* Brooks, Report on the Stomatopoda, Voyage of Challenger, Zool., XVI, II, p. 48.

Diagnostic characters: A *Lysiosquilla* having 15 or 16 teeth on the dactylus of the raptorial claw. The cylindrical eyes have hemispherical cornea. In one specimen the diameter of the eye is 2 mm. The telson of *excavatrix* is rectangular in shape. On its ventral surface are two lateral spines which are large and movable. Between these are 9 or 10 small immovable spines.

Remarks: This species was described by W. K. Brooks from specimens taken at Beaufort, N. C. I have examined only two specimens of this species: One at Beaufort, N. C., and one kindly loaned by Dr. H. V. Wilson of the University of North Carolina. Both specimens were taken at Beaufort, N. C. The specimen in the Bureau of Fisheries Biological Station checked very closely with Brooks' description of this species. The specimen from the University of North Carolina checks in most characters with the original description except that the dactylus of the raptorial claw had only 13 teeth. Brooks (1886, p. 50) states that there are no structural differences between the sexes of *excavatrix*, except in the organs of reproduction. Therefore, it would seem that this difference in the number of teeth is not due to a difference in sex. I have not examined a sufficient number of specimens to form an opinion as to the cause of this variation.

The species is reported as being common at Beaufort, N. C. It has not been taken in South Carolina but the United States National Museum has a specimen for Charlotte Harbor, Florida, taken by the

"Albatross" at Station 2410. The Museum of Comparative Zoology has two specimens from Mobile, Alabama (No. 7904).

Lysiosquilla scabricauda (Lamarck)

Squilla scabricauda Lamarck, Hist. Anim. sans Vert. **5**: 188. 1818.

Diagnostic characters: A *Lysiosquilla* having 9 or 10 strong teeth on the dactylus of the raptorial claw. The T-shaped, bilobed eyes are set at a slight angle to the stalk. In one specimen the corneal axis of the eye is 11 mm. while the peduncular axis is 8 mm. The posterior part of the body is depressed and triangular in shape. The telson is spinulose. The lateral processes of the first exposed thoracic segment are not produced.

Remarks: The Charleston Museum has two specimens: One was taken off Charleston Harbor by a fisherman in the summer of 1931; the other specimen is a Gibbes specimen. The label with the latter does not give the date of collection and for the locality gives only South Carolina. It is probable, however, that it was collected before 1850 in or near Charleston Harbor. The species ranges southward from South Carolina to Brazil, including the Bahamas, West Indies, and the Gulf of Mexico. It has also been recorded from West Africa.

The genus *Chloridella* (*Squilla* of most authors) is represented in the Carolinas by three species.

KEY TO SPECIES OF CHLORIDELLA

A¹ Dactylus of raptorial claw with 5 teeth; lateral process of first exposed thoracic segment spatuliform; median dorsal spine of telson long and slender; eyes large ..... *neglecta* (Gibbes)

A² Dactylus of raptorial claw with 6 teeth.

B¹ 5 teeth well developed, 6th very small; eyes small; lateral process of first exposed thoracic segment spiniform; median dorsal spine on telson blunt; median carina on carapace not bifurcate *dubia* (M. Edwards)

B² All 6 teeth well developed; eyes large; lateral process of first exposed thoracic segment spiniform; median dorsal spine on telson short; median carina on carapace bifurcated anteriorly ..... *empusa* (Say)

Chloridella neglecta (Gibbes)

Squilla neglecta Gibbes, Proc. Amer. Assoc. Adv. Sci. **3**: 200. 1850.

Diagnostic characters: Dactylus of raptorial claw bears 5 teeth. The median dorsal spine of the telson is very pronounced, being at least 2 mm. long. The lateral processes of the first exposed thoracic segment are produced into a bifurcate spine, the uppermost part being spatuli-

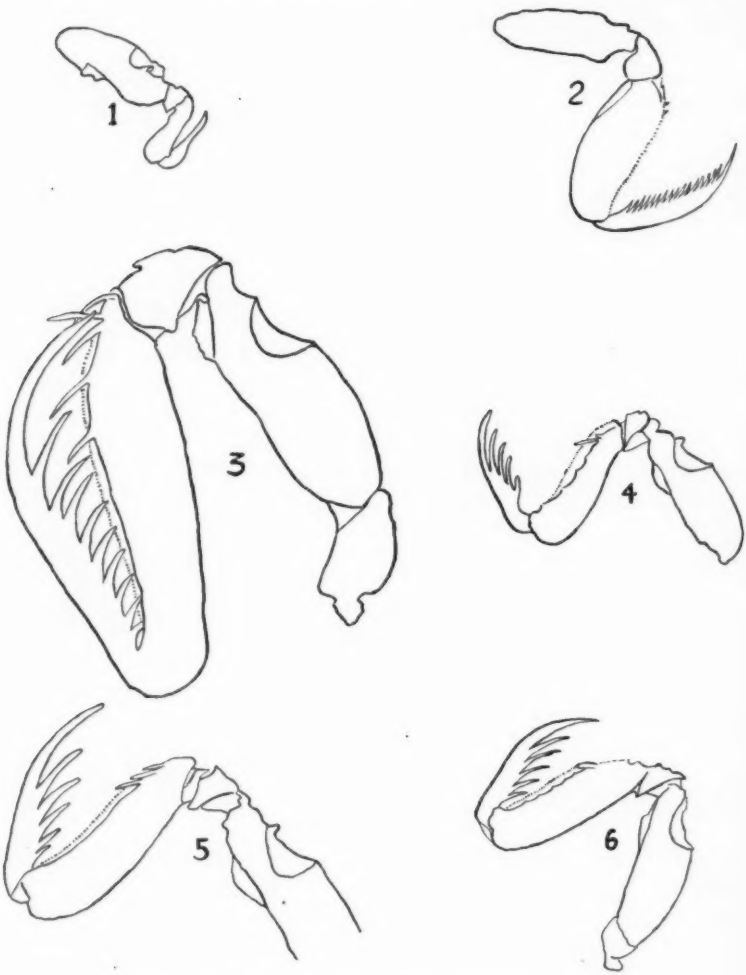
form. The median carina of the carapace is bifurcate. The eyes, like those of *empusa*, are large.

Remarks: This species was originally described by L. R. Gibbes from a specimen taken in Charleston Harbor in 1848. For 85 years no other specimen of *neglecta* was reported and, as far as I have been able to ascertain, no specimens of this species existed since Gibbes' type specimen was destroyed. However, on October 31, 1933, a specimen was obtained from a local shrimp trawler working off Charleston Harbor. This rediscovery was published in Leaflet No. 5 of the Charleston Museum. Since that time, I have examined four more specimens of this rare stomatopod, three from Charleston Harbor and one from Beaufort, N. C.

In color all the fresh specimens agree with the description published in Leaflet No. 5. All agree in having the lateral process of the first exposed thoracic segment spatuliform, and in having 5 teeth on the dactylus of the raptorial claw. In all specimens the median spine of the telson is much longer than in the closely related form *C. empusa*. A table of comparative measures of the specimens examined follows:

	TOTAL LENGTH	LENGTH CARAPACE	MEDIAN SPINE OF TELSON	EYESN	
				Corneal Axis	Pedunculer Axis
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Chas. Mus. No. 4463	63	16	2.5	4	4
Chas. Mus. No. 33.355	115	26	2	5	5
Chas. Mus. No. 34.340.1	92	22.5	3	5—	4.5
Chas. Mus. No. 34.340.2 (In U. S. N. M.)	70	18	2	4	4
Beaufort Specimen	117	30	2	5	5

Two recent specimens (taken November 14, 1934) from just outside the north jetty of Charleston Harbor were taken on mud bottom in about 15–18 feet of water. The Beaufort specimen was found in a jar with two other stomatopods labelled "*Squilla empusa*." There were no further data with these specimens but it is safe to assume that they were taken near Beaufort, N. C. In the U. S. National Museum, I examined some 50 lots comprising over 80 specimens of *Chloridella empusa*, with which *neglecta* might have been confused. I did not find a single specimen of *C. neglecta*. The National Museum now has one of the specimens from off Charleston Harbor, S. C., taken November 14, 1934.



FIGS. 1–6. Outline drawings of the raptorial dactyli of:

1. *Gonodactylus oerstedii* Hansen
2. *Lysiosquilla excavatrix* Brooks
3. *Lysiosquilla scabricauda* (Lamarck)
4. *Chloridella neglecta* (Gibbes)
5. *Chloridella dubia* (M. Edwards)
6. *Chloridella empusa* (Say)

All actual size.

Chloridella dubia (M. Edwards)

Squilla dubia Milne Edwards, Hist. Nat. Crust. **2:** 522. 1837.

Diagnostic characters: Dactylus of raptorial claw bears six spines; the proximal spine is poorly developed. The eyes of *dubia* are small. The average measurements of five specimens are as follows: Corneal axis —4 mm.; axis of eye and stalk —5 mm. The median carina of the carapace is not bifurcate. The median spine on the telson is blunt. The lateral processes of the first exposed thoracic segment are bifurcate; the uppermost portion is blunt and often is not recurved as in *empusa*.

Remarks: The Charleston Museum has a number of specimens of this species, and although it occurs regularly at Charleston, it is by no means abundant. On the east coast of America *C. dubia* is known to range southward from South Carolina to Brazil, including the West Indies. On the west coast, there are specimens in the United States National Museum from El Salvador, Costa Rico, Ecuador, and Peru.

Chloridella empusa (Say)

Squilla empusa Say, Jour. Acad. Nat. Sci. Phila. **1:** 250. 1818.

Diagnostic characters: The dactylus of the raptorial claw bears six well developed teeth. The eyes are large. The average measurements of ten specimens are as follows: Corneal axis —5.6 mm.; axis of eye and stalk —5.6 mm. The median carina of the carapace is bifurcate at its anterior end. The median spine on the telson is short. The lateral processes of the first exposed thoracic segment are bifurcate and the uppermost part is elongated into a spine which recurves forward.

Remarks: This is the common stomatopod found in abundance in both North and South Carolina. It ranges from Massachusetts to Texas. It is also reported from West Africa.

On the coast of North Carolina, *C. empusa* is known to the fishermen by the common name "Salt-water Crawfish." Around Charleston, S. C., it is sometimes referred to as "Shrimp Mammy." This name, however, also applies to the squid *Loligo*.

A specimen which was kept for some time in a marine aquarium contributes some interesting data for a few notes. This specimen fed exclusively on shrimp and would not eat dried fish food, shredded fish, or oyster. It would eat about two small shrimp a day. Swimming rapidly, it would attack the shrimp from above, pin it down, and then grasp it with the raptorial claws. It appeared to have no trouble biting through the integument of the shrimp. The *empusa* spent much of its time swimming around the aquarium. On numerous occasions it would

swim close to the surface and roll its back out of the water, in the manner of a "porpoise." Twice in two months it shed its skin.

THE CHARLESTON MUSEUM,
CHARLESTON, S. C.

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NOTES ON THE OCCURRENCE OF A WHALE SHARK (RHINEODON TYPUS)

In the Cape Fear River, near Southport, N. C.

By H. H. Brimley

Plate 46

In the early afternoon of Wednesday, June 6, 1934, a wire was received from Louis T. Moore, secretary of the Wilmington, N. C., Chamber of Commerce, to the effect that a fifty-foot whale was ashore near the Quarantine Station, Southport Harbor, and that it was ours for the asking.

On reaching Wilmington the next morning we got in touch with Mr. R. C. Fergus, who operates a large fish-dealing establishment in Wilmington, and with him, we found the tail and one of the claspers of the animal that had been removed from the body by Mr. Fergus the day before for exhibition at Carolina Beach. That morning, however, their removal to the garbage dump had been ordered by the health authorities. Hence, the photograph of a shark's tail among a scattering growth of native grasses and scrub pines.

Definite identification was simple. The sandpaper-like surface of the skin, the heterocercal tail, with its white spots, the side keels of the caudle peduncle, together with the enormous size of the tail, indicated that nothing but a large whale shark could have carried such an organ.

The thin posterior edge of the caudal had become partially dried out during its twenty hours or more exposure to a warm wind, thus pulling the lobes closer together, and I feel sure that Mr. Fergus' measurement of 9 feet, 10 inches between the tips of the lobes, made the day before, is approximately correct, my measurement of the partially dried tail being 9 feet, 5 inches.

The tail had been severed from the body at the smallest part of the caudal peduncle, immediately forward of the base of the lobes. Measured from the center of that cut in a straight line, the upper lobe showed a length of 8 feet, 1 inch; the lower lobe, measured in a similar manner, being 4 feet, 9 inches in length. From the center of the cut to the near-

est point in the concave curve of the rear edge of the caudal fin, 2 feet, 9 inches. The diameter of the several vertebra was 3 inches, and the superficial area of the caudal fin was about 18 square feet.

The cut through the caudal peduncle, made at its smallest cross section, was 13 inches wide by 10 inches deep. The lower edge of the tail was white for perhaps two feet from the base, and a trace of yellow showed on the keel.

Some shrinkage, in addition to that estimated for the measurement between the tips of the lobes, had undoubtedly taken place. I believe that the measurements of the section through the caudal peduncle would have been as much as 14 by 11 inches when the cut was made about 20 hours previously and that the lobes might each have been from 1 to 2 inches longer if measured when the tail was freshly cut.

The single clasper that had been saved along with the caudal fin measured 24 inches in length by 4½ inches in average diameter, with little or no taper. It showed no color other than white.

The spots on the tail were irregular, both in their distribution and in shape, the largest measuring 1 inch by 1½ inches. Their outlines were not sharply defined. On one side of the tail, about 12 inches from the tip of the upper lobe, a group of spots ran together in an irregular line about 6 inches in length.

Mr. Fergus, whose statements were confirmed by a colored fisherman who was aboard the boat with him when visiting the specimen the day before, gave us the following additional particulars:

Estimate of total length, 40 feet.

The body was submerged on a shoal in the Cape Fear River approximately 3½ miles above the town of Southport, and not on the river beach. An effort was made by Mr. Fergus to drag the body off the shoal, and beach it for exhibition purposes, but without success. It seemed to be either bedded down, or to possess so high a specific gravity as to be beyond the power of a small gas boat to move, and it also seemed to be firmly anchored against the pull of the tides. Only the upper part of the first dorsal was exposed above the surface.

The spots on the back were described as white, the largest approximating 3 inches in diameter. A convenient metal cap of a Mason fruit jar was used in indicating their apparent size. The spots seemed to gradually decrease in size down the side of the body.

The color of the back was described as "slaty." Perhaps slaty brown, or brownish slate might be more descriptive of the general color of the upper part of the tail as we saw it.

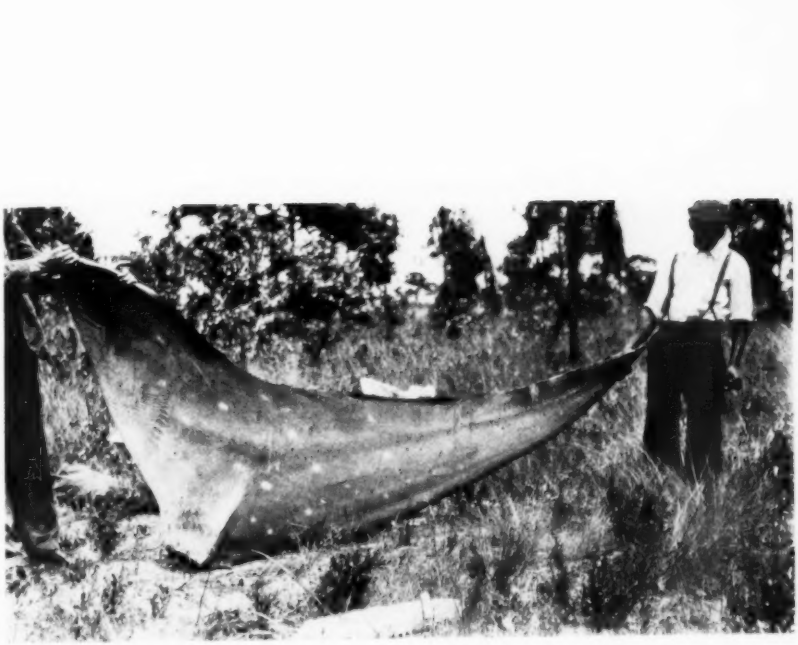
The most noticeable feature of this find is the occurrence of a whale shark so far north of all previous records on the Atlantic coast of the United States. Previous to this, the most northern Atlantic point from which the species has been recorded was Ormond Beach, Florida, in 1902, Ormond being some three hundred and fifty miles south of the mouth of the Cape Fear River, which is in latitude approximating 34° N. The most northern Pacific record for the species is Cape Inubo, Japan, in latitude 35° 39′ N. According to Dr. E. W. Gudger, this is the seventy-eighth recorded specimen, the seventy-seventh having been recorded by him recently from Acapulco, Mexico.

The Gulf Stream is probably responsible for carrying this great fish so far north of the previously known northern limit of the species on the west side of the Atlantic.

Two deep cuts in the side of the body, probably resulting from contact with a vessel's propeller, appeared to be the cause of the animal's death.

STATE MUSEUM,
RALEIGH, N. C.

PLATE 46



THE PERFECT STAGE OF A LEAFSPOT FUNGUS ON RED MULBERRY

By Frederick A. Wolf

Plates 47 and 48

In connection with a survey of the diseases of trees in the Duke Forest, Durham, N. C., the writer encountered one that involves the foliage of red mulberry, *Morus rubra* L. This disease appears, from records of collections and exsiccati, to be of common occurrence in the eastern United States and throughout many of the countries of Europe. The causal fungus is generally regarded as one of the pycnidial fungi, *Phleospora Mori* (Lév.) Sacc. A study of its morphology, however, shows that its structural characteristics accord more nearly with those of the genus *Cercosporella*. In addition, it has been found that the ascigerous stage develops, in spring, in the old lesions of decaying leaves. The present report, therefore, deals briefly with the writer's observations on the morphology and taxonomy of the pathogen.

CONIDIAL STAGE

The disease can be recognized by the presence of a few to many, circular, brown spots on all of the foliage. The lesions on drying become fuscous to ochraceous, and have a broad, dark brown border (pl. 47). Conidia are formed on both leaf surfaces but are most abundant on the lower surface. They may form in gelatinous masses in such abundance that on drying they appear as a pinkish incrustation. The conidia are cylindrical, curved, blunt-pointed, hyaline, many-septate, and are provided with oil droplets (pl. 48, A). They vary in size from 20 to 60 x 5 to 8μ. The conidiophores form fascicles that project approximately 10μ above the leaf surface (pl. 48, C).

Apparently this fungus was first named *Fusarium maculans* Berény. (Atti Congr. Mil. 1844), in 1844. A more complete account of it was given two years later by Léveillé[1] under the name *Septoria Mori* n.sp., in which account he states "Tres petite especé, dont la présence est

[1] Léveillé, J. H. Description des champignons de l'Herbier du Museum de Paris. Ann. Sci. Nat. Bot. **5**: 249–304. 1846.

announceé sur les faces des feuilles par un grand nombre de taches brunes. . . . les spores, linaires, simples, melangeés, avec une matière gelatineuse, forment en sortant un filet tres court et blanc. Quand elle existe sur un arbre elle affecte presque toutes les feuilles, et en cause promptement le desséchement et la chute."

In 1884, Saccardo[2] employed the name *Phleospora Mori* (Lév.) Sacc. and assigned to synonomy *Septoria Mori* Lév., *Fusarium maculans* Beréng., and *Fusisporium Mori* Mont. (Bull. Soc. Agr., 1853). The writer is at a loss to know how Léveillé and Saccardo could have interpreted any structures possessed by this fungus as pycnidia, but it may be that they regarded the leaf glands as conidial conceptacles.

It also appears highly probable that *Phleospora moricola* (Pass.) Sacc. (*Septoria moricola* Pass.) is identical with the fungus under consideration. Saccardo[3] indicated that such might be the case in his query "An ejusdem forma peculiaris autumnalis?" Collections made in early summer, in North Carolina, have less robust conidia with fewer septations than those collected in late summer or in autumn, thus indicating that *P. moricola* may be an autumnal form of *P. Mori*.

PERITHECIAL STAGE

Leaves bearing the conidial stage were collected in September, 1933, and stored out of doors at Cambridge, Mass., during the following winter. By May, 1934, black perithecia were abundantly present on the upper leaf surface of the old lesions. These perithecia ranged in diameter from 60 to 80μ and were quite superficial, the basal portion only being sunken within the leaf tissues (pl. 48, D). The asci are clavate, fasciculate, aparaphysate, 35 to 40 x 5.5 to 6.5μ (pl. 48, D). The ascospores are 12 to 15 x 3.5 to 4μ (pl. 48, E).

Cultures, originating from ascospores, were made by permitting the ascospores to be discharged on inverted agar plates. Conidia were not developed on the resultant growth but the colonies had the appearance of colonies isolated from conidia. Unfortunately proof of the genetic connection of the perithecial and conidial stages was not established because mulberry trees were not available for inoculation experiments. Evidence of connection, therefore, rests upon the presence of perithecia within old conidial lesions, upon the similarity of cultures isolated from conidia and from ascospores, and upon the fact that the connection of

[2] Saccardo, P. A. Sylloge Fungorum **3**: 577. 1884.
[3] Saccardo, P. A. Sylloge Fungorum **3**: 578. 1884.

certain other fungi bearing similar conidial and perithecial stages has been established.

TAXONOMY

The perithecial stage of the pathogen on mulberry is manifestly a species of *Mycosphaerella* (*Sphaerella*). At least three species of this genus have been listed to occur on mulberry, namely *Sphaerella morialbae* Cke., *S. morifolia* Pass., and *S. Mori* Fkl. The fungus under consideration is clearly distinct from the first two of these species. It may, however, be identical with *Sphaerella Mori*. Saccardo[4] was inclined to this opinion, as is indicated by his statement "Spermogonium *Septoria Mori* Lév. sistit," although he was not able to establish proof. He points out, furthermore, that no one seems ever to have seen the ascigerous stage nor has he himself come upon a description of it ("Statum vero ascophorum nullibi observare nec descriptum invenire mihi contigit"). Specimens collected by Auserwald and identified as *Sphaerella Mori* Fkl. were found by Saccardo[4] to be *Phyllosticta osteosporam* Sacc. In spite of the uncertainty of the identity of *Sphaerella Mori*, in the mind of Saccardo, and of the inadequacy of Fuckel's description of this fungus it seems reasonable to regard the pathogen on mulberry as *Mycosphaerella Mori* (Fkl.), and to emend its description according to the present findings.

Mycosphaerella Mori (Fkl.) emend. (Symb. Myc. **1**: 106. 1869).
Syn. *Fusarium maculans* Berény. Atti Cong. Mil. 1844.
Septoria Mori Lév. Ann. Sci. Nat. Bot. **5**: 279. 1846.
Fusisporium Mori Mont. Bull. Soc. Agr., 1853.
Phleospora Mori (Lév.) Sacc. Syll. Fung. **3**: 577. 1884.
Cercosporella maculans (Berény.) n. comb.
?*Septoria moricola* Pass. Myc. Univ. n. 384.
?*Phleospora moricola* (Pass.) Sacc. Syll. Fung. **3**: 578. 1884.

Peritheciis gregariis, epiphyllis, minutis, sphaeroideis, erumpenti-superficialibus, membranaceis, fuscis, apice pertusis, 60–80μ diam.; ascis basi fasciculatis, clavatis, aparaphysatis, apice rotundatis, 8-sporis, 35–40 x 5.5–6.5μ; sporidiis subdistichis, curvulis, 1-septatis, ad septum constrictis, haud v. paullo inaequalibus, loculo superiore paullo crassiore, 12–14 x 3.5–4μ.

Hab. in foliis morientibus et putridis Mori sps. in Brittania, Gallia, Italia, Germania, Austria inf. et Amer. bor.

Status conidicus—Statum conidicum *Cercosporella* sistit. Maculis

[4] Saccardo, P. A. Sylloge Fungorum **1**: 536. 1882.

singulis v. paucis in quoque folio, orbicularibus, 2–6 mm. diam., centro expallentibus, brunneo-marginatis; caespitulis amphigenis plerumque hypophyllis, pallide subcarnosulis; conidiophoris stomate oriundis, brevibus, hyalinis; conidiis vermicularibus, 3–10-septatis, ad septa constrictis utrinque obtusulis, crassatulis, guttulatis, hyalinis, 20–60 x 5–8μ.

Hab. ad folia viva Mori sps.

Specimens bearing perithecia and others bearing conidia have been deposited in the Farlow Herbarium, Harvard University, Cambridge, Mass.

Acknowledgment is gladly made of the help given by D. H. Linder, G. D. Darker, and W. W. Diehl.

SUMMARY

This report is concerned with the morphology of a common leafspot fungus of mulberry. It possesses a conidial stage that is commonly designated *Phleospora Mori* (Lév.) Sacc. and that appears properly to belong to the genus *Cercosporella*. An ascigerous stage develops in spring on fallen leaves. This stage seems to be identical with *Sphaerella Mori* Fkl., an inadequately described form that was suspected by Saccardo of being connected with *Phleospora Mori* (Lév.) Sacc. (*Septoria Mori* Lév.). The pathogen is herein described and illustrated.

BOTANY DEPARTMENT,
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PLATE 47

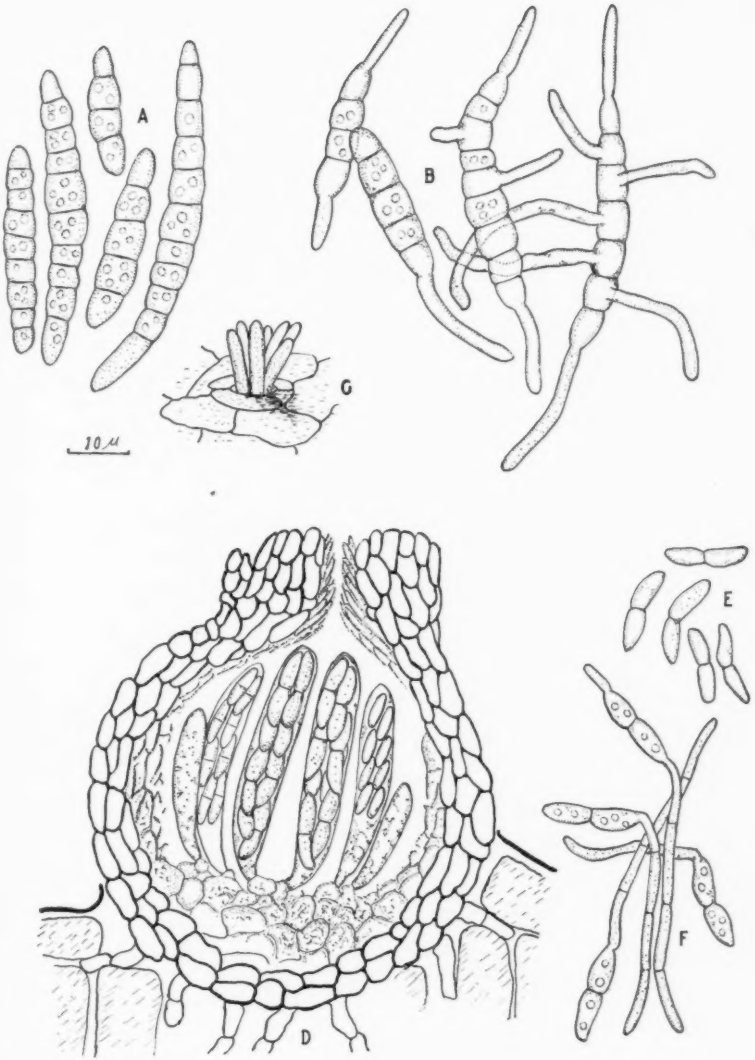
LEAVES OF RED MULBERRY, SHOWING LESIONS PRODUCED BY THE CONIDIAL STAGE OF MYCOSPHAERELLA MORI

Lower leaf surface shown by the outer leaves and upper surface by the middle leaf

EXPLANATION OF PLATE 48

A. Conidia of the *Cercosporella* stage.
B. Conidiophores.
C. Germinating conidia.
D. Perithecium of *Mycosphaerella Mori* in vertical section.
E. Ascospores that were forcibly expelled onto a slide placed above the ostioles.
F. Germinating ascospores.

PLATE 48



A NEW SPECIES OF KEITHIA ON RED CEDAR[1]

By J. K. Miller

Plate 49

During the summer of 1934, the writer collected in the Duke Forest, near Durham, North Carolina, a discomycetous fungus that occurs upon the leaves of red cedar, *Juniperus virginiana* L. This fungus was found to belong to the genus *Keithia* and to differ in certain important features from the other species of this genus that have previously been reported to attack gymnosperms. It was, therefore, decided to make a study of its morphology and development.

HISTORICAL

Four species of *Keithia* have previously been described, all of which occur on gymnosperms. The genus is based upon a fungus that, in 1880, was first given the name *Phacidium tetrasporum* Phillips and Keith. This fungus was collected in Scotland by the Rev. J. Keith (5) where it was found to be parasitic upon the leaves of common cedar or juniper, *Juniperus communis* L. In 1892, Saccardo erected the genus *Keithia* (7) with *Phacidium tetrasporum* as the type.

Dr. W. G. Farlow (4), in 1884, described as *Stictis tsugae*, a fungus that he found during the summer of 1883, on hemlock, *Tsuga canadensis* Carr., in New Hampshire. This fungus was referred by Saccardo (6), in 1889, to *Propolidium tsugae*, but Dr. E. J. Durand (3), in 1913, changed it to *Keithia tsugae*, with Farlow as the authority for the change.

During 1908 and 1909, Dr. J. J. Davis (2) collected, in Wisconsin, on the leaves of American arbor vitae, *Thuja occidentalis* L., another member of the genus *Keithia*. These collections were sent to Durand and he regarded the fungus as *K. thujina* but did not describe it until 1913 (3).

In the summer of 1915, Professor R. A. Harper and Dr. B. O. Dodge collected, in New Jersey, on living leaves of *Chamaecyparis thyoides* (L.) B.S.P. another member of the genus *Keithia*. These collections were

[1] From a thesis submitted in partial fulfilment of the requirements for the Master of Arts degree at Duke University. Acknowledgment is made of assistance given by Dr. F. A. Wolf.

sent to Dr. J. F. Adams (1) and he described it and affixed the name *K. chamaecyparissi*.

APPEARANCE OF THE KEITHIA DISEASE ON RED CEDAR

This disease may be found to involve only a small portion of the leaves or it may be very abundant. It can be recognized by the presence of black apothecia, the fruiting structures of the causal fungus, that project prominently above the leaf surface. Usually a single apothecium only occurs on each diseased leaf although as many as three have been noted, all occurring on the morphological lower surface. The fungus may cause the death of the leaves so that they eventually become dry and brown. Infected leaves are not shed prematurely but persist as long as normal leaves of the same age. The apothecia instead of falling away after the discharge of the ascospores, remain attached to the leaf indefinitely. They disintegrate together with the leaves, and their weathered remains can be recognized even on the fallen leaves.

The observations that have thus far been made do not warrant a definite statement as to the economic importance of this *Keithia* disease. It apparently does not involve a large proportion of the cedars within the Duke Forest. Groups of affected trees have been found throughout the area, and those so affected show a marked lack of vigor. The disease, in the writer's opinion, is of potentially serious consequence to the growth of red cedar as a forest and ornamental tree in the area around Durham, North Carolina.

MORPHOLOGY OF THE FUNGUS

A study of the development of the fungus was facilitated by examination of material collected at different times throughout the summer and by the use of sections of infected leaves that had been appropriately killed, embedded in paraffin, and sectioned. By crushing and teasing apart the developing apothecia and by examining paraffin sections of infected leaves bearing apothecia one finds (1) that the vegetative parts of the fungus are intercellular (fig. 2); (2) that a compact brown fungoid stroma forms immediately beneath the epidermis and above the palisade parenchyma; (3) that the apothecium arises from this stroma, and the epidermis is ruptured by the developing apothecium; (4) that the epidermis does not persist as a flap or fold over the surface of the apothecium; (5) that the young apothecium is at first a cushion-shaped mass of fungoid parenchyma tissue, visible only with the aid of a hand lens. At this stage the leaves are not discolored but are entirely green; (6)

that apothecia are mature 5 to 8 weeks after inoculation. At this stage when viewed in vertical section they are hemispherical with a broad short stalk (fig. 1). In outline they are circular to oval and their consistency is carbonaceous. The surface is convoluted and rugose. Mature apothecia vary in height from 300–400μ and in diameter from 400–525μ (fig. 1). The outer surface of the excipulum consists of a compact layer that ruptures by irregular fissues to permit discharge of ascospores. It consists of brown fungoid cells that appear distinctly black until they have been separated and examined under the microscope. The inside of the apothecium is completely filled with asci and paraphyses that arise from a well developed hypothecium. At first the asci are hyaline but as the eight spores are cut out the entire ascus and contents begin to turn brown. At maturity the asci measure 40–50 x 80–90μ (fig. 4). The wall of the asci consists of a double layer, a thin inner one and a thick outer one that is thinner at the apex. Preparatory to the discharge of ascospores the outer wall ruptures at the thinner apical portion and the inner wall then elongates. In this condition the ascus (fig. 5) will measure 130–135 x 35–40μ and the individual ascospores are more easily seen, due to their change in arrangement within the ascus.

The ascospores are hyaline at first but become brown at maturity. They are two-celled and very unequal, the distal cell always being the larger. Mature ascospores range in size from 28–30 x 15–18μ (fig. 6). They are forcibly expelled as shown by the fact that they have been allowed to collect on agar in inverted petri dishes. Discharge was accomplished by placing infected cedar leaves on moist paper with the apothecia directed upward. Apparently the ascospores are discharged singly as shown by the presence of groups of eight ascospores on the agar, each spore being separate from the others.

The paraphyses are numerous and are at first hyaline and entire, becoming segmented and brown at maturity. They are slightly longer than the asci, often branched at the distal end. The distal end is 3.5–4μ in diameter, the proximal end, 2–3μ in diameter (fig. 3).

GERMINATION

Attempts have been made to germinate ascospores on the surface of potato agar and in drops of water on slides placed in moist chambers. In most cases no germination whatsoever followed. In a few cases, however, after 24 hours in drops of water or on the surface of agar plates, short germ tubes developed. Germination may occur from either cell

of the ascospore, however the smaller cell will usually germinate first. Apparently growth ceases soon after the germ tube appears.

TAXONOMY OF THE FUNGUS

Two of the known species of *Keithia* are 2-spored, two, 4-spored. If the genus be amended to include 8-spored forms, a change which appears to be in accord with results of investigation of nuclear phenomena and spore formation in certain other ascomycetes, then the fungus under consideration is a species of *Keithia*.

Since no species of *Keithia* with 8 spores has been described and since this 8-spored species occurs on *Juniperus*, it is assigned the specific name *juniperi*. A brief summary of the characteristics of the new species follows:

Keithia juniperi n. sp.

Hypophyllous, subepidermal at first, erumpent, slightly elevated and cushion-like, black, circular-ovate, height 300–400μ and diameter 400 x 525μ at maturity, excipulum dark. Asci hyaline at first, olive brown at maturity, broadly ovate, 40–50 x 80–90μ, 8-spored. Ascospores hyaline and continuous at first, olive brown and two-celled at maturity, 15–18 x 28–30μ, cells very unequal, distal end always the larger. Paraphyses numerous, slightly longer than asci, apex clavate, hyaline and continuous at first, olive brown and septate at maturity, apex 3.5–4μ in diameter, base 2–3μ in diameter.

Ascomata hypophyllia innata, deinde erumpentia, pulvinata, atra, orbicularia vel ovata, 300–400μ, atra, 400–525μ lata.

Asci ovati, brunnei, 40–50 x 80–90μ, octispori. Sporae brunneo-olivascentes, 15–18 x 28–30μ, septe ad apicem posteriorem inaequaliter divisae.

Paraphyses furcatae, clavato-incrassatae, ad apicem 3.5–4μ diam., ad basem 2–3μ diam.

Hab. in foliis vivis *Juniperi virginianae*.

For the convenience of mycologists, type specimens have been deposited in the Farlow Herbarium, Harvard University, Cambridge, Mass, in the New York Botanical Garden, New York, N. Y., in the Herbarium of the Department of Plant Pathology, Cornell University, Ithaca, N.Y., and in the Herbarium of the New York State Museum, Albany, N. Y.

SUMMARY

This report deals with a new species of *Keithia* that is parasitic on red cedar. Affected trees are lacking in vigor. The disease can be recognized by the presence of black apothecia on the lower leaf surface.

The morphology of the pathogen on cedar is quite like other known species of *Keithia*, except that it has eight spores. Two of the other species of *Keithia* are 2-spored and two are 4-spored.

The fungus is herein briefly described as *Keithia juniperi*, n. sp.

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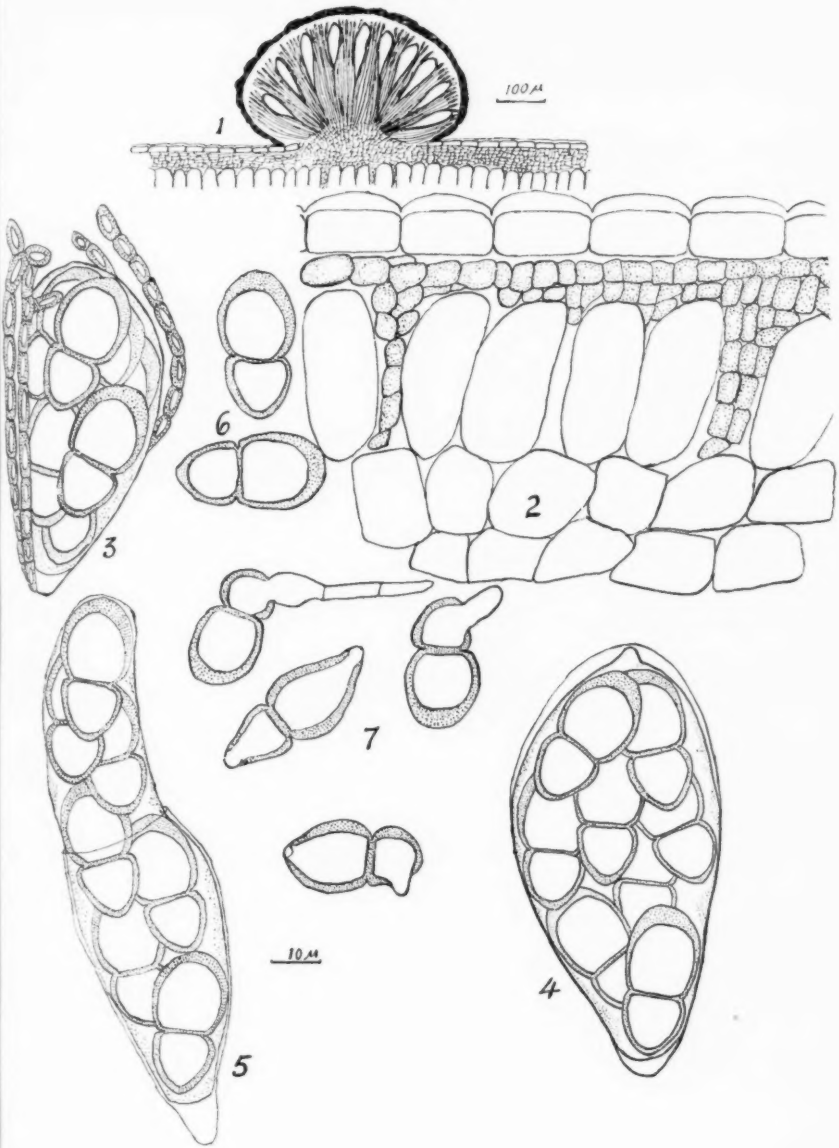
EXPLANATION OF PLATE 49

Keithia juniperi n. sp.

Fig. 1. Microtome section of apothecium on host tissue.
Fig. 2. Host tissue permeated from fungoid cells.
Fig. 3. Mature ascus with ascospores and paraphyses.
Fig. 4. Mature ascus and ascospores.
Fig. 5. Mature ascus with outer wall ruptured, before spore discharge.
Fig. 6. Mature ascospores.
Fig. 7. Stages in the process of germination of ascospores.

PLATE 49



CAVITY-DEVELOPMENT AND SPORE-FORMATION IN PISOLITHUS TINCTORIUS

By CAROLINE A. LANDER

PLATES 50 AND 51

Pisolithus tinctorius Pers. has been known under a number of names as *P. arenarius* A. and S., *Polysaccum pisocarpium* Fr., and *Polysaccum crassipes* D.C. Coker and Couch (2) using Persoon's Synopsis Fungorum as a starting point for Gasteromycetes, accepted *Pisolithus tinctorius* and were supported in their acceptance by Fischer in Engler and Prantl (3). Tulasne (11) in 1842 described the species and gave a short account of its gross morphology.

Bruns (1), in 1874, distinguished the three types of hyphae in the rhizomorph and stalk, the specific type in the tramal plate, and the fertile hyphae with clamp connections in the cavities. He noted that the peridium is made up of hyphae which surround the peripheral cavities in contrast with the specially formed complex structure in *Scleroderma*; that the capillitium is lacking; and that development and maturation of the cavities is progressive. The base of the fruiting body is composed of a confused network of hyphae. Above this is a layer in which the first indication of cavities is noticeable because of the swelling and darkening of the hyphae in indistinct, limited groups. Next is the region of definite cavities and of the tramal plates which surround the cavities. The cavities contain branching hyphae, the tips of which swell to form the basidia. At the top of the fruiting body peridioles with mature spores are shed by the disintegration of the peridium. Progressive formation of the cavities from the upper stalk region continues for some time.

Lohwag (7) separated *Pisolithus* from *Scleroderma* because of the difference in their peridia, and because of the progressive development and maturation of the cavities in *Pisolithus*. Coker and Couch (2) mentioned the abundance of the black jelly containing a yellow pigment between the peridioles and hyphae of the peridium, and purple pigment in the spores; also the fact that the spores increase in size after leaving the basidium.

No record of a cytological study of *Pisolithus* has been found in the literature. Fusion of the two nuclei in the basidium in the spireme stage has been reported for two related forms, *Nidularia* (Fries, 4) and *Hydnangium* (Petri, 9). Fries made a detailed study of the synaptic stages of the fusion nucleus; of the two divisions; and of the passage of the nuclei into the spores. A similar account has been given for *Scleroderma lycoperdoides* (Lander, 6).

Maire (8) described the presence and action of centrosomes in the division of the nuclei in the basidium of several species of Gasteromycetes.

MATERIAL

The material of *Pisolithus tinctorius* Pers. was collected during August, 1933, at Chapel Hill, North Carolina. It was found on well-drained gravel and sandy soil, in old fields, and in waste places. The fruiting bodies were killed in formalin-acetic-alcohol, Flemming's medium, or chrom-acetic solutions. The material was allowed to remain in 70% alcohol for six months with frequent changes in order to dissolve the pigments. The triple stain gave the best results for cytological study, and Haidenhain's iron-alum-haematoxylin with fast green as a counter-stain was best for differentiating hyphae.

OBSERVATIONS

Cavity-development

Representative stages in development of the fruiting body of *Pisolithus tinctorius* were studied from an immature stage one-half inch in diameter to that of a mature body shedding peridioles. Very young stages were not found. However, the development takes place progressively and regions of the youngest forms studied showed cavity differentiation, the lower part being homogeneous throughout.

The basal region is composed of a confused network of narrow thin-walled hyphae. It is fairly compact, with few spaces between the filaments. The hyphae, all of which are similar in appearance, are interwoven in an irregular manner. The hyphae contain hemispherical pads at the cross walls; have occasional clamp connections; are sparsely branched, and are composed of long binucleate cells.

With development, this compact region of tangled hyphae expands and the hyphae become looser in arrangement. Scattered irregularly throughout this region are portions of hyphae which become particularly loose, so much so that spaces appear between the hyphae. In the

regions of the lighter areas the hyphae begin to differentiate. This is earliest manifest in the greater density of protoplasm and in the increased diameter of the cells.

There follows a rapid increase in the differentiation of the hyphae. They divide rapidly forming short cells which are as broad as long. These cells are binucleate, have a strong affinity for fast green stain, and contain on their cross-walls very prominent hemispherical pads. The pads are extremely large and absorb safranin stain most rapidly.

The hyphal filaments branch frequently and these in turn rebranch. The branches are short, often not over three or four cells in length. Thus there is in each cavity primordium a main axis or central group of three or four long filaments with many short branches giving the hyphae a tufted or feather like appearance.

A number of these primordia of fertile branches are formed. At first these have no definite arrangement and are massed into a confused, irregular group (fig. 27). In contrast to the original fundamental hyphae, the filaments are not interwoven and are looser in arrangement. A group of such tufted branches is the earliest indication of a cavity. These are the hyphae from which the basidia will arise later and which will fill the fertile cavity. In the stage just described the cavity has no definite boundary or shape.

After the first differentiation of hyphae, the number of groups of basidial primordia increases. Along with the increase goes a continued development in size and number of branches of the individual filaments. The main axes assume a radial direction and grow toward the center of the cavity.

There is no indication of the original fundamental hyphae in the cavity. Early in the process of differentiation they disappear from the region. They become organized in the tramal plates surrounding the cavities. In contrast to *Lycoperdon* (Lander, 5; Swartz, 10) there seems to be very little tearing of the fundamental tissue in the cavity-formation. Instead, the disappearance of the fundamental hyphae from the cavities is brought about by the change of position of the filaments caused by the growth and expansion of the fruiting body; and by a differentiation of many of the hyphae of the region into fertile primordia.

After the first hyphal differentiation the cavities have a definite size and shape, tending to be spherical (fig. 28). They are bounded by the tramal plates in an even contour, and are compactly and completely filled with the hyphal branches of the fertile primordia. The tip cells

of the short lateral and secondary branches appear swollen; prominent hemispherical pads are present on the majority of the cross-walls; and clamp connections are abundant (fig. 1).

The cavities increase in size and become more regular in shape. The expanse is general in all directions involving the growth and rearrangement of the tramal hyphae as well. The tramal plates assume the typical compact appearance with the majority of the hyphae, making up each plate, parallel to each other and with their lateral walls appressed. A few long filaments, main axes of the basidial primordial groups, radiate toward the center of the cavity, each with abundant short lateral branches (fig. 29).

The tip cells of such branches become greatly swollen and are the basidial primordia. These cells ultimately increase to five times their original size. Clamp connections may be present even on the basal wall of a basidium (fig. 1).

Four spores occur regularly on a basidium. Though in some cases five may be formed, only four develop. The spores have attained about three fourths of their mature size and in many cases their walls have become roughened before they are freed from the basidium. Growth of the spores seems to continue a short time after the collapse of the basidium.

The cavity now has a definite spherical character. It is filled with the crowded mass of spores. The basidia have disintegrated, with the exception of a few near the outer margin of the cavity; and a few scattered filaments of the hyphal branches remain (fig. 30). The tramal plates have become very thin in proportion to the enlarged cavities. Tramal hyphae are thick-walled and compactly pressed together (fig. 29).

A pigmented jelly fills the tramal spaces and the cavity surrounding the spores. The jelly contains a yellow pigment in such abundance that it is most difficult to distinguish cells. The mature spores contain a purple pigment.

At maturity the tramal plates split, their hyphae nearest the cavity form a brittle layer around the cavity making the peridioles. The peridioles, the gritty particles in the fruiting body, are later freed by the breaking of the thin peridium.

The maturing and freeing of the peridioles take place by degrees so that disintegration may be seen in an upper layer while the lower cavities are beginning to develop.

Spore-formation

All the cells of a young fruiting body are binucleate. In a basidial primordium the two nuclei lie close together. The enlargement of the cell is accompanied by an increase in nuclear size. At the time of fusion the nuclei are approximately three times as large in diameter as when first observed.

These nuclei move toward each other and lie in close proximity for a short time (fig. 3). The nuclear reticulum is thickened and becomes irregular. In it more darkly stained portions may be identified. The irregularity and density of the reticulum increase as the nuclei approach each other. The chromatic material of each nucleus tends toward the side nearest the other nucleus (figs. 3, 4). The prominent nucleolus may retain a central position or may migrate to one side.

As the nuclei come together they become flattened in the plane of contact (fig. 4). The reticula are flattened against the appressed nuclear membranes. The membranes disintegrate and the two reticular masses intermingle (fig. 5). A number of examples of such a stage were found. The fusion nucleus is long in proportion to its width, retaining somewhat the shape of two nuclei before fusion; two nucleoli are prominent; and one chromatic reticulum is present. Later only one nucleolus is distinguishable and the nucleus is spherical (fig. 6).

A definite spireme before and at the time of fusion such as Fries (4) reported for *Nidularia* and Petri (9) for *Hydnangium* could not be distinguished.

The fusion nucleus, 2.5–3μ in diameter, lies in the apical portion of the swollen basidium. It contains a large nucleolus, around which is a clear space, at least in fixed material. Throughout the rest of the nuclear cavity, however, is a reticulum in which more darkly stained portions may be distinguished (fig. 6). The reticulum becomes thickened, and forms a spireme. The spireme aggregates toward one side of the nucleus, surrounding the conspicuous nucleolus. This stage resembles synizesis, characteristic of the heterotypic prophases of higher plants (fig. 7).

The threads loosen from the synizetic condition and form an open spireme (figs. 8, 9). Later the spireme contracts and breaks into four parts (fig. 10). It could not be determined whether each of these four parts is double or four-parted.

In the next stage observed the division spindle is formed. It is a long, narrow spindle with few distinguishable fibers, lying in the apical region transversely to the longitudinal axis of the basidium. The spin-

dle poles reach the walls of the basidium and at each pole is a centrosome (figs. 11, 12, 13, 14).

Four pairs of chromosomes are spread along the spindle. The pairs are sometimes separated so that they appear as eight individual chromosomes (figs. 12, 13, 14).

In a few cases, as illustrated in figure 11, four groups of chromatic bodies which may be interpreted as two pairs or as four double chromosomes are present in the center of the spindle and two chromatin fragments lie near one pole. A streaming of the chromatic material along the spindle and its breaking into fragments are frequent. It is difficult to interpret this anaphase division stage for two reasons: the chromosomes are extremely small, and fragments are common. It would seem that the separation of paired chromosomes takes place in the first division rather than, as is common in the higher plants, in the second division.

At a late telophase stage two pairs or four individual chromosomes are grouped close together at each pole (fig. 15).

Two daughter nuclei are organized. The rarity of the two-nucleate as compared with the one- and four-nucleate stages suggests that interkinesis is of short duration. The second division, occurring simultaneously in both daughter nuclei, takes place rapidly. The spindles of the second division, like that of the first, lie in the apical portion of the basidium transverse to its longitudinal axis; they make a right or oblique angle with each other (figs. 16, 17, 18, 19). The spindles are in close proximity, so that it is difficult to distinguish one from the other.

Two pairs or four single chromosomes are seen at the equatorial plate of each spindle. These separate and move to the poles (figs. 16, 17). In anaphase stages two chromosomes are clearly distinguishable at each pole (figs. 18, 19, 20). As a result of the second division four nuclei are organized.

These four nuclei move to the central and basal part of the basidium, where they remain for a short time. Small, narrow protuberances, the sterigmata, now appear at the distal end of the basidium. These outgrowths elongate, and each enlarges at its distal end; the enlargements become the spherical spores. As the spores begin to enlarge, a large vacuole is formed in the basidium below the nuclei; the increase in size of this vacuole seems to cause the nuclei to be pushed toward the apical region of the basidium.

A darkly stained body suggestive of a centrosome is visible near each of the four nuclei (fig. 21). Fiber-like strands radiate from each centrosome to the corresponding nuclei (fig. 21). The nuclei become stretched in the direction of the centrosome (fig. 24). The centrosomes move toward the sterigmata.

Changes occur in the nuclei about the time the spores have attained two-thirds their mature size and show signs of the thickening and roughening of their walls. The prominent nucleolus is no longer visible in each nucleus; the reticulum is darkly stained and contains irregular masses of darker material (figs. 23, 24). The membrane disintegrates, the reticulum condenses and is drawn out along the fibers. The chromatic material seems to be neither in the form of a definite spireme nor in that of individual chromosomes, but rather in an irregular mass on the fibers (fig. 22). This mass could be interpreted either as a twisted condensed thread or as a group of chromosomes so massed together that they are individually indistinguishable. This stage may be interpreted as preparation for the division of the nucleus following in the spore and which is completed in the spore after the passage of the fibers and chromatic material into the spore (fig. 22). Figure 25 shows the anaphase stage of division in the spore. Two chromosomes go to each pole. The mature spore is binucleate (fig. 26).

SUMMARY

Basidial cavities in the fruiting bodies of *Pisolithus tinctorius* arise by the differentiation of the fundamental hyphae. They are first distinguishable because of the increased diameter of the cells and their strong affinity for fast green stain.

The differentiated hyphae divide rapidly, branch and rebranch to form tufts of cells. A number of such groups radiate toward a common point, all other hyphae disappearing in the region.

By general growth of the fruiting body, and by continued differentiation large spherical cavities are formed.

The fundamental hyphae become parallel and compressed against each other surrounding the cavities to form the tramal plates.

The tip cells of the branches of the differentiated hyphae increase to five times their original diameter and form basidia.

Four spores are regularly formed on each basidium.

At maturity the cavity is filled with spores, surrounded by heavy-walled tissue, and freed as a peridiole.

The differentiation and maturation progresses by degrees from the top to the base. The upper stalk region remains meristematic for some time.

An abundance of a pigmented jelly fills the cavities and the tramal hyphae.

All the cells of the fruiting body are binucleate, have hemispherical pads on their cross-walls, and occasional clamp connections.

The fusion of the two nuclei of the basidial primordium takes place while the chromatic material is in an irregular thickened reticulum.

The fusion nucleus forms a spireme and then passes through a stage suggestive of synizesis.

The spindle of the first division lies in the apical portion of the basidium transverse to its longitudinal axis. Four pairs or eight individual chromosomes spread along the spindle. A centrosome is present at each pole. In the late telophase two pairs or four individual chromosomes are grouped at each pole.

The spindles of the second division are likewise transverse to the longitudinal axis, and are in close proximity to each other or at right angles to each other.

Four chromosomes are spread along the spindle and two go to each pole.

The four nuclei formed move to the base of the basidium, but later are pushed to the apical region by a large vacuole.

After the formation of the spores the nuclei, attached by fibers to centrosomes, are pulled toward the sterigmata.

The nuclei lose their characteristic form and are carried into the spore as an irregular mass of chromatin on fibers, a stage in preparation for division which is completed later within the spore.

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The writer wishes to express appreciation to Dr. E. M. Gilbert and to Dr. C. E. Allen for helpful suggestions throughout the investigation. Also to Dr. J. N. Couch for assistance in collection and identification of material.

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EXPLANATION OF FIGURES

PLATE 50

Fig. 1. Basidial primordia branch. Fusion of nuclei in uppermost basidium, and clamp connection at the base; hemispherical pads on the cross-walls.
Fig. 2. Binucleate basidial primordium.
Figs. 3, 4, 5. Fusion of nuclei in basidium.
Fig. 6. Fusion nucleus in basidium in spireme stage.
Fig. 7. Same in synizesis.
Figs. 8, 9. Spireme after synizesis.
Fig. 10. Diakinesis.
Figs. 11–14. First division spindle in basidium of fusion nucleus.
Fig. 15. Late telophase of the first division.
Figs. 16, 17, 18. Second division of the nuclei in basidium.
Figs. 19, 20. Late telophase of second division.
Fig. 21. Four nucleate basidium with centrosomes present.
Figs. 22, 23, 24. Change in nuclei and passage into the spores.
Fig. 25. Division in spore; two chromosomes going to each pole.
Fig. 26. Binucleate mature spore.

PLATE 50

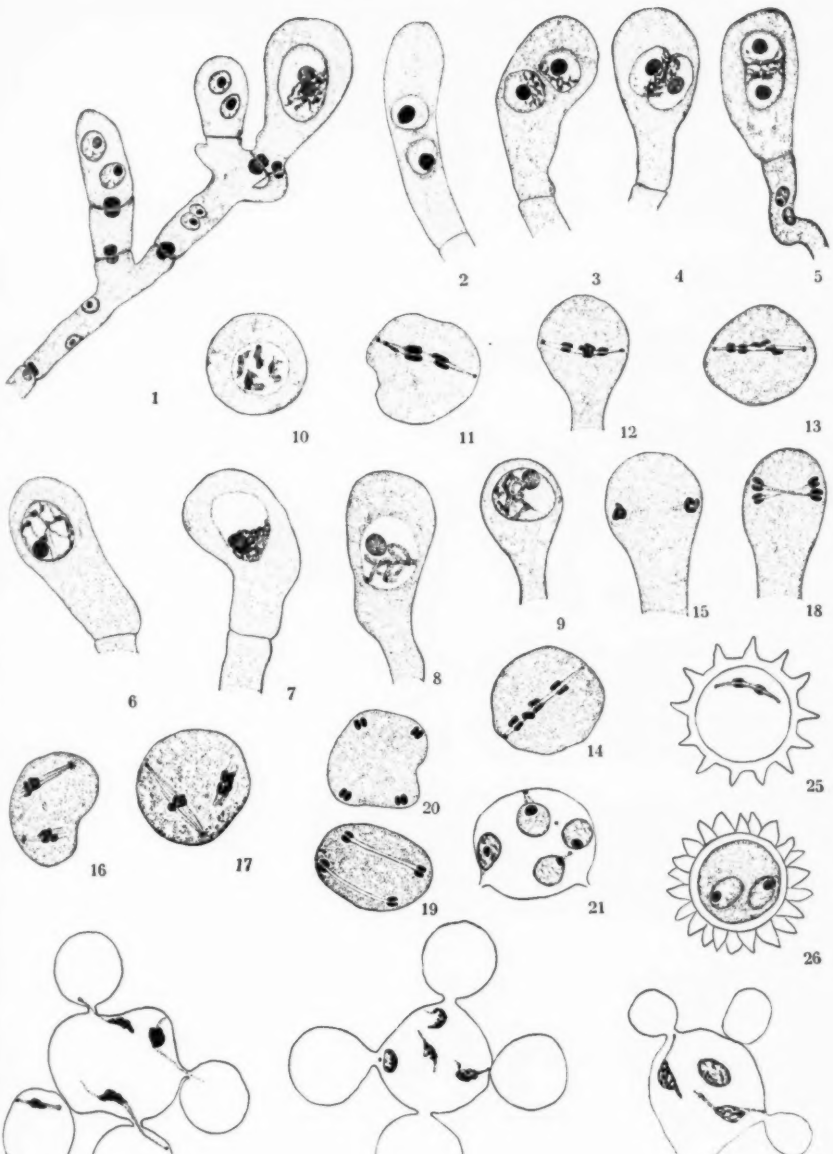
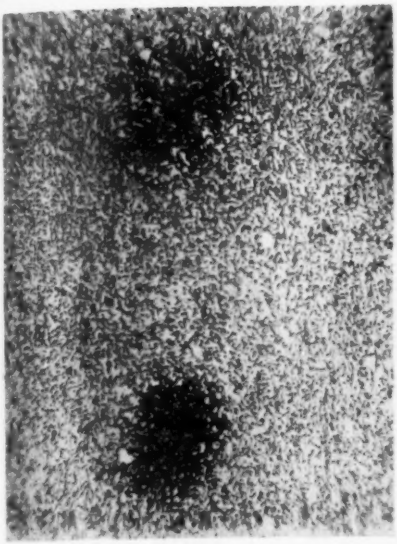


Plate 51

Fig. 27. Cavity primordia. × 225.
Fig. 28. Early stage in cavity formation; tufts of basidial primordia branches radiating inward. × 488.
Fig. 29. Cavity of older stage. × 488.
Fig. 30. Portion of tramal plate and two cavities with basidia and spores. × 488.

All drawings were made with an Abbé camera lucida at table level. A Spencer 1.5 mm. achromatic objective, N. A. 1.25, and a Leitz 15 × ocular were used, giving a magnification of about 3000 times. Plate reduced one-third.

PLATE 51



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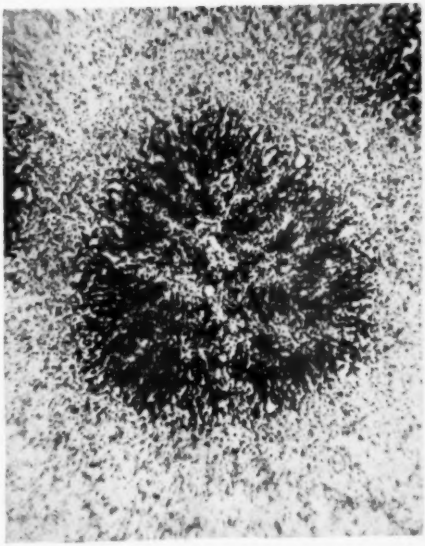

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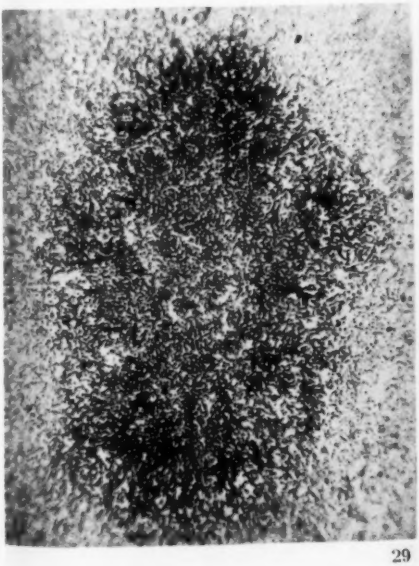

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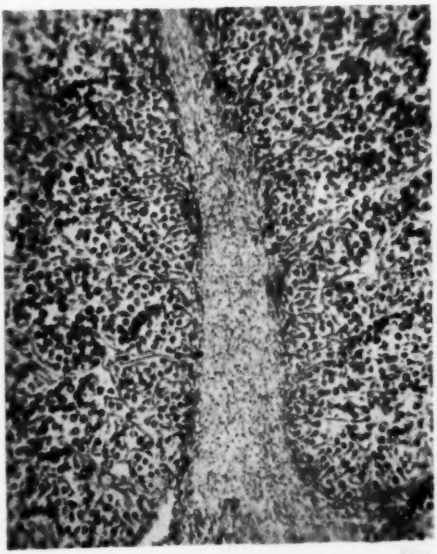

30

ACHLYA RECURVA CORNU FROM NORTH CAROLINA

By Dennis H. Latham[1]

Plate 52

This rare fungus, first incompletely described by Cornu, has since been recorded by Hartog (6) and Miss Forbes (4, 5) from England, the former of whom gives no description, by Minden (8) from Germany who describes it rather fully but gives no illustrations, and by Lund from Denmark who had a very small amount of material and admittedly gives an incomplete diagnosis. If the plant illustrated by Miss Forbes is the same as ours, the egg structure as shown by her is incorrect. Since the fungus is incompletely known, it would seem of interest to give a more complete diagnosis with illustrations at the present time.

Achlya recurva Cornu. Ann. Sci. Nat. Bot., Ser. 5, **15**: 22. 1872.

Growth fairly vigorous, but somewhat less vigorous than in *Achlya Orion* or *A. americana*, reaching a diameter of about 3 cm. Hyphae 20–90μ thick near the base, the average being thinner than in most Achlyas. Sporangia only fairly abundant in young cultures, being very scarce in older ones, primary sporangia apical, renewed by cymose branching, typically broadest in the middle or toward the base, gradually tapering toward and rounding off at the tip. Spore development, discharge, and germination as typical for the genus; spores 11μ to 16μ, averaging 11μ thick when encysted. Gemmae sparingly produced in old, healthy, aqueous cultures, abundant in contaminated water cultures and on potato agar containing 2 per cent sucrose. Oogonia usually lateral, on short, curved branches, which are from one to two times as long as the diameter of the oogonia; spherical but with numerous (up to 35), prominent cylindrical or slightly tapering protuberances 5–10μ thick by 5–16μ long, usually about 9μ long, the ends truncate and with very thin walls. Oogonia 37μ to 84μ (protuberances not included), rarely as small as 25μ thick, the average being about 42.8μ. Oogonial wall unpitted except for the thin tips of the protuberances. A few atypical oogonia of irregular shape, sometimes intercalary and elongated, or twisted, or constricted in the middle, or with enormously elongated protuberances, are found in each culture. In such oogonia the eggs also are atypical in shape. Antheridial branches present on approximately seventy-five

[1] The writer wishes to express his appreciation to Dr. J. N. Couch of the Department of Botany in the University of North Carolina, Chapel Hill, N. C., under whose guidance the work was done and manuscript prepared.

per cent of the oogonia; typically single, rarely two on an oogonium; usually androgynous, arising as a rule from the oogonial stalk or not rarely from the main hypha near the stalk origin, occasionally diclinous. The antheridium is short or long and usually applied laterally to the oogonium, becoming empty during the development of the eggs. Fertilization tubes present but difficult to follow because of the protuberances. Eggs 19–26μ, averaging 23μ thick, typically spherical but may become ovate to broadly elliptical due to pressure; 1 to 18, usually 4–8 in an oogonium, wall hyaline, 2μ thick; usually not completely filling the oogonium; when mature, eccentric with a single, small, oil globule. Germinating upon maturity, or remaining quiescent for several months under certain conditions.

Deficiencies in previous descriptions make a close comparison of our plant with Cornu's species somewhat difficult. Cornu (3) mentions the oogonia covered with obtuse spines, the oogonial stalk being bent in an arch, and the number of eggs being usually from six to eight. He does not describe the antheridia. In Minden's more complete description the sporangia are described as being long-cylindric or slightly spindle-shaped, the secondary ones being few, the oogonial stalks recurved or bent like a bow and the walls furnished with many, blunt, hollow projections; the diameter of the oogonia from 50–90μ with the spines 7–11μ long; antheridial branches arising from the oogonial stalk, the main thread, or from another thread and also bent like a bow; the antheridia cylindrical or clavate and small; the eggs spherical, 1–25, mostly about 10 in an oogonium, 22–27μ thick.

According to Lund (7) the oogonia are terminal on the main hyphae or on side branches which are bent; the oogonial wall is set with numerous blunt outgrowths, 6.6–13.2μ, mostly about 9μ in length, unpitted; the oogonia 49.5–72.6μ thick (without outgrowths); oospores 23–30μ thick, 3–9 in an oogonium. Lund's material was very scanty and he did not observe the sporangia nor did he see any antheridia on the few oogonia present in the culture.

The fungus described by Cornu, Minden, and Lund as *Achlya recurva* comes within the range of variation expected in this group and our plant agrees well with their descriptions, the only discrepancy being that Minden describes the oogonia as having 1–25 eggs, usually 10, while we have found 1–18, usually 4–8, a difference easily accounted for by variation or by the personal equation.

This fungus is closely related to *Thraustotheca primoachlya*. In fact it was at first thought to be that species, due to the close resemblance

of the oogonia and the fact that the eggs germinate so readily in both species. It is, however, distinguished from that species by the absence of the *Thraustotheca* type of sporangia which develop in cultures of *T. primoachlya* that are a few days old. The protuberances on the walls of the oogonia in *Achlya recurva* are longer than those on the oogonia of *T. primoachlya*, they are more numerous and symmetrically arranged, except on the few atypical oogonia which develop in most cultures. When the eggs in *T. primoachlya* germinate, they produce the *Thraustotheca* type of sporangia, while in *A. recurva* the germinating eggs produce the *Achlya* type of sporangia. Another striking difference between the two fungi is in the size of the oil globules in the ripe eggs, those in *A. recurva* being distinctly smaller than in *T. primoachlya*.

This fungus was collected from a moderately dry, red clay soil in a cotton field on the Central Experiment Station Farm at Raleigh, N. C., October 18, 1934. The original isolation was made by placing a small quantity of the soil in a Petri dish, covering it with water, and adding several pieces of boiled hemp seed. After about two days, when a fungus growth was visible, the pieces of hemp seed were washed with sterile water and transferred each to a separate Petri dish of sterile distilled water. When growth had continued for another twenty-four hours, a single hyphal thread was cut off and transferred to sterile water in a hollow ground slide. A very small piece of boiled hemp seed was added. The slide was then placed in a moist chamber for twenty-four hours. The hyphal tip continued to grow, becoming attached to the hemp seed. This culture was then transferred to sterile water in a Petri dish and was the source of all subsequent cultures.

Growth of the fungus on boiled hemp seed is moderately vigorous, the hyphae extending to a distance of 1.5 cm. from the seed in five to seven days. The mycelium forms a dense mat, i.e., the hyphal threads are very numerous. On yellow corn kernels the growth is not so vigorous as on hemp seed. The hyphae do not exceed 1.5 cm. in length in ten days and the mycelium does not form as dense a mat as on hemp seed. Growth of the fungus is scant on boiled acorns (*Quercus stellata*). The hyphae grow to a length of one to one and one-half centimeters in ten days. The number of hyphal threads which grow out from the acorn is very much smaller than the number produced on hemp. On all of the above named media young cultures of this fungus produce sporangia fairly abundantly. Sporangial development ceases almost entirely in cultures which are a week or more old. Oogonia are developed quite profusely in cultures on hemp and yellow corn, but not so abundantly

on acorns. Gemmae are produced in aqueous cultures a week or more old which have not had fresh water added to them during the time. The fungus grows well on two and one-half per cent potato agar containing two per cent sucrose, but produces neither sporangia nor oogonia. Gemmae are produced abundantly on potato agar.

There are very few records of egg germinations in the Saprolegniaceae. Trow (10) reported oospore germination for *Achlya americana* variety *cambrica* in 1898. Weston (11) reported the germination of eggs in *Thraustotheca clavata* in 1918. Coker (1) says in his discussion of *Achlya apiculata* var. *prolifica*, "This variety is the only member of the Saprolegniaceae in which we have been able to observe sprouting eggs." In *Thraustotheca primoachlya* the eggs germinate at room temperature after about ten days to two weeks (2). Usually when the eggs of that species germinate the germ tubes grow out through the projections on the oogonial wall for a short distance and form sporangia which later liberate a number of spores. Schlösser (9) working with three species and several varieties of *Saprolegnia* reported egg germination. He found that the normal rest period of the eggs varied from about three weeks in some species to three months or more in others. By subjecting the eggs to a temperature of $-22°$ to $-24°$C. he found that many of them, in one case 50 per cent, had germinated after three days. In *Achlya recurva* the eggs mature in three days as indicated by their structure and are capable of germinating immediately. (These cultures were grown in an incubator at 20° to 24°C.) When the eggs germinate the germ tubes grow out through the protuberances. In a culture less than four days old a single oogonium containing four germinated eggs was observed. The single germ tube from each egg had grown out, each through a separate protuberance, to a distance of about fifty to seventy-five microns and a sporangium was formed at the tip of each hypha. The sporangia had each matured and discharged about five to eight spores which were encysted at the tips of the sporangia. Other cases of germination were seen in which the germ tubes had grown to a length of about two hundred microns before forming sporangia.

SUMMARY

Achlya recurva Cornu, a very rare and incompletely known species of water mold, isolated from a red clay soil on the Central Experiment Station Farm at Raleigh, N. C., October 18, 1934, is described. The fungus is characterized by the recurved oogonial stalks and by the numerous prominent cylindrical or slightly tapering protuberances which

adorn the oogonial walls, and also by the fact that the eggs are capable of germination a few days after maturing.

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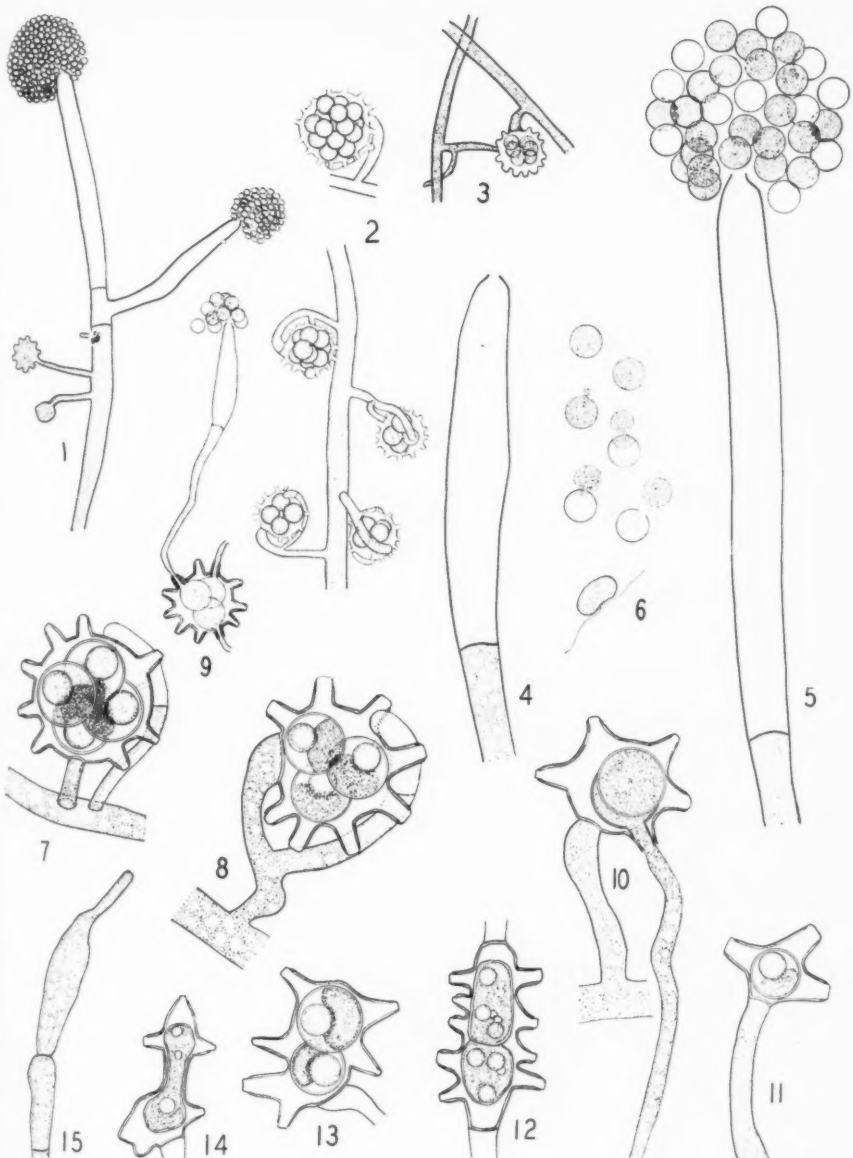
EXPLANATION OF PLATE 52

Achlya recurva

Fig. 1. Habit of fruiting. × 93.
Fig. 2. Habit sketch showing oogonia and antheridia and one separate oogonium above. × 110.
Fig. 3. Oogonium showing diclinous antheridial branch. × 93.
Fig. 4. A typical empty sporangium. × 440.
Fig. 5. Sporangium with spores clustered at tip. × 440.
Fig. 6. Stages showing germination of cyst into a reniform spore. × 440.
Figs. 7 and 8. Typical oogonia with androgynous antheridia and eccentric eggs. × 880.
Fig. 9. Germination of eggs in an oogonium. Only one of the three sporangia which had formed are shown. × 208.
Fig. 10. An oogonium with germinating eggs. × 440.
Fig. 11. Oogonium with a single egg. × 440.
Figs. 12–14. Three atypical oogonia. × 440.
Fig. 15. Gemmae. × 208.

PLATE 52



A REMARKABLE NEW RHODODENDRON

By W. C. Coker

Plates 53 and 54

Rhododendron Ashleyi n. sp.

This description is drawn up from one plant in flower.

Plant about 3 feet high, very compact and fastigiate, foliage dense, bark resembling that of other rhodondendrons; leaf blades lance-elliptic, somewhat twisted and bent at the tips, tapering at both ends, 6–7.5 cm. long by 1.4–2 cm. broad (some much smaller), about $\frac{2}{3}$ mm. thick; margin even or slightly roughened, tip mucronate, midrib very prominent below, sunken above, other veins small and obscure. Petioles stout, about $1\frac{1}{2}$–2 cm. long, petioles and lower side of leaves at first covered with pale brownish gray scurf which is partly worn off at the time of flowering and apparently entirely so by fall. Twigs of the year greenish, scurfy, stout. Flowers in a rather compact head, of about the same number as in *R. maximum*; corolla with a spread of about 3 cm., not glandular; petals all separate or (apparently about half) with the lowermost two fused about one-third the way up, the 4 lower alike, about 2 cm. long and about equal in width throughout, the upper one somewhat longer and with more undulate edges, more or less folded, strongly so and constricted below, this constriction containing the nectar. Color bright rose with a slight magenta tint, most intense at the tips and sides, fading to white below; upper lobe with light lemon yellow central area occupying the larger part of the broader distal half, this area very obscurely or less often plainly dotted with a few greenish splotches. Calyx lobes quite separate, oblong, blunt or slightly pointed, very variable in size without much regard to position, 3–5 mm. long, occasionally one up to 1.2 cm. their margins rosy; calyx and pedicel set with short rosy hairs; pedicels about 1.5–2 cm. long. Stamens normally 10, frequently 2 or 3 fused together to near the anthers, their lengths quite unequal, about 1–1.5 cm. long; filaments pure white, most of them at least with minute viscid glands; anthers very short, knob-like, dull yellow, not normal looking; pollen extremely scarce, probably none of it normal. Ovary about 3–4 mm. long, 2 mm. wide, longitudinally grooved, green, minutely glandular (in the particular ovary sectioned having six primary cells, imperfectly 12 due to the long recurved placentae). Style stout, bent slightly upward near its enlarged tip, about 1.2 cm. long, white; stigma flat, tuberculate, bright rose.

Bud scales boat-shaped and abruptly sharp-pointed to obovate with a long tapering point, 12–15 mm. long, greenish above, brown below, very minutely viscid glandular along central region of back.

Growing on a hill in Ashe County, N. C. (farm of H. M. Ashley), two miles from Lansing, surrounded by *Rhododendron maximum*, *Kalmia latifolia*, and various hardwoods in undisturbed forest (elevation about 2500 ft.). In bloom June 19, 1935, and still blooming and with some expanding buds on June 29; in faded bloom July 2, 1934. Raymond F. Ashley, collector.

This very remarkable plant is almost certainly an extreme mutant of *R. maximum*, as there is no other rhododendron in the vicinity and it resembles that species in the scurf instead of scales on the under side of the leaves and in the time of flowering. The flowers have the same color as pink forms of *maximum*. The plant is very probably entirely sterile, as indicated by the lack of pollen and of fruit. Its most remarkable characters are: entirely separate petals or at most the two lower slightly fused, entirely separate sepals, long, narrow, densely set leaves, and compact growth. The entire absence of disk-like scales on the under surface of the leaves shows that it is not connected with the *minus* group.

The writer visited Mr. Ashley and took a photograph of the blooming plant June 29, 1935. Mr. Raymond Ashley showed us three small ones left in the woods and said he was sure there were at least three more within the same small area of woods. Mr. Ashley had moved several others some time before in an effort to grow them but they had died. The large plant illustrated was moved into the yard of Mr. H. M. Ashley and is the only one large enough to flower. It is in healthy condition but these and all the others are of very slow growth. The smallest one seen had two stems and was only a few inches high. Either the younger plants are repeated mutations of apparently exactly the same kind or they are seedlings of the large plant. As this plant is apparently quite sterile, the first suggestion seems the more probable. In this case the appearance of repeated apparently identical mutations is a very remarkable occurrence in nature.

We take pleasure in naming this plant for Mr. Raymond F. Ashley, who first sent us a twig and leaves of it in May 1932; another in September, 1932; fading flowers in July 1934 and fresh flowers in full bloom in June 1935.

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PLATE 53

RHODODENDRON ASHLEYI. PHOTOGRAPH OF PLANT AND DRAWINGS OF FLOWER, PETALS, AND BUD SCALES

PLATE 53

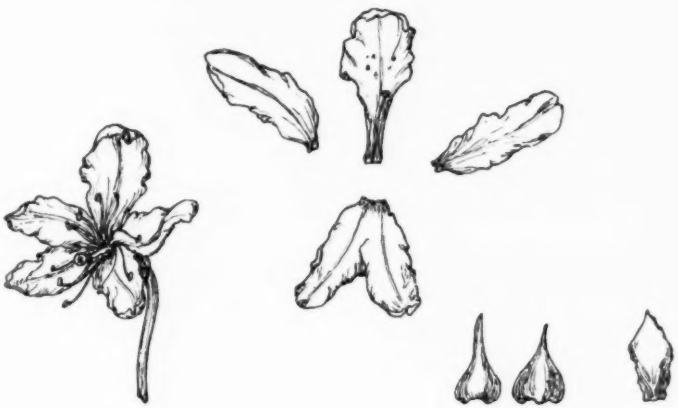

PLATE 54

RHODODENDRON ASHLEYI. ENLARGED ONE-FIFTH

PLATE 54

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